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STUDIES OF EMOTIONAL REACTIONS. I. 'A PRELIMINARY STUDY OF FACIAL EXPRESSION'[1]

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The study of facial expression is probably as old as the human race. From earliest times, men have read in the changes of countenance produced by the movements of the facial muscles, the thoughts, feelings and motives of their fellows. Witness to this is found in the traditions, fables, and proverbs of all peoples. For instance, "Where there is a high look, there is a proud heart," "He has evil eyes," "He has an honest face," "I can read it in his face," and so on, are all common phrases the like of which may be found in literature. As with most sciences, the study of facial expression was outlined by Aristotle (1) in his 'Physiognomonica.' During the sixteenth century physiognomy became an independent science, with many students. The seventeenth and eighteenth centuries saw its decline from science to charlatanism. Sir Charles Bell, whose 'Essay on the Anatomy of Expression' was first published in 1806 was the first to make a really scientific study of emotions in terms of the muscles which produce the various facial expressions. It remained for Darwin (2) to sum up the centuries of speculations and generalizations and to point the way for systematic study of facial expression. For some reason this branch of investigation of human behavior has not been followed up. So far as I am

[1] I wish to acknowledge my indebtedness to Prof. H. T. Moore of Dartmouth College for his supervision and guidance in this study.

able to find, the only work since Darwin on the facial expressions, in which anatomical analysis and photography are used is Schultze's (16) 'Experimental Psychology and Pedagogy.' His photographs are excellent but he makes little analysis of them and gives few details as to the stimuli used to arouse the various expressions. Langfeld (12) (13) in 1918 published the results of an experiment which is in part related to the present problem. In this investigation the subjects were asked to make a judgment of the emotion expressed by various portraits presented to them. Feleky (9) and Ruckmich (15) have made similar studies.

The Problem

This experiment was designed for the purpose of recording and analyzing facial expressions of various persons who were subjected to a controlled series of situations of a more or less emotional nature. The faces were recorded by means of a motion picture and ordinary cameras. As a check, several of the subjects went through a second series of situations in which they voluntarily aroused the expressions which were recorded and analyzed in the regular experiment.

Method

A studio was set up in a regular laboratory room. A specially constructed table, behind which the subject was seated, was placed in the center of the set-up. In the wall 8 feet from the subject, several small openings were cut, through which the cameras were focused. Nineteen subjects were used; all were men, either students or instructors in Dartmouth College.

The subjects were given verbal instructions somewhat as follows: "I am making a study of facial expressions. All you have to do is to be seated behind the table and act as naturally as possible in the various situations that follow. Don't try to be emotional or to show a 'poker face.' Try to forget the cameras and act natural." At the end of each situation the subject was given a small blank on which were listed the various feelings or emotions which might have been aroused

during the situation. For instance, the slip for situation one, had the following suggestions: Boredom, Abstraction, Dreamy, Indifference, Interest (kind), also a space labeled, Feelings other than those mentioned. The subject was asked to check such listed feelings as he experienced and name any others which might have occurred.

The following series of situations were used as stimuli:

(1) Classical music. Phonographic reproduction of 'Die Walkure' by Wagner.

(2) Jazz music. Phonographic reproduction of 'My Man' played by a jazz orchestra.

(3) Paintings of nudes. 'The Birth of Venus' by Bougue-reau and 'Sleeping Venus' by Georgione were used.

(4) Paintings of Christ. 'The Crucifixion' and 'The Trinite' by Rubens.

(5) Vulgar pictures of direct sex appeal. A strip of pictures depicting various sexual acts was used.

(6) Pictures to arouse horror or disgust. The illustrations in 'The Diseases of China' by Jefferies and Maxwell (11) were used. These are quite detailed and for most subjects very effective.

(7) Odors. The subject was given a tray containing eight small bottles. These bottles contained dilute forms of cinnamon oil, spirits of peppermint, etc. The bottles were placed in a row facing the subject and he was told to uncork the bottle nearest him, smell it, recork and replace in the tray, take the next bottle and so on down the line. The next to the last bottle was labled 'Syrup of Lemon' but actually contained very strong ammonia.

(8) Frogs. A bucket with a paper cover was placed beside the subject. Through the top of the table at which the subject was seated a polished iron rod extended. The subject was told to grasp the rod with his left hand. Using his right hand he was to remove the cover from the bucket, without looking, and to 'feel around' in the bucket. The bucket contained two live frogs in about an inch of water.

(9) Electric Shock. On the left of the subject was placed another paper-covered bucket. He was told to grasp the rod

with his right hand and to 'feel around' in this bucket with his left. The bucket contained about six inches of water. Concealed wiring leading from the secondary of an induction coil was connected to the rod, and to the bucket. While the subject was feeling around the circuit was closed and he received a moderately strong shock.

In each situation, the subject was given instructions as noted above by the experimenter who then went into the next room and operated the cameras. In no case was there anyone in the room with the subject while the actual situation was proceeding.

At the end of the regular series, three subjects whose responses had been expressive were asked to go through a check series. They were asked to voluntarily express or 'register' (1) Abstraction and Contemplation; (2) 'Pep' and Interest; (3) Lust; (4) Religious Feeling; (5) Disgust and Repulsion; (6) Pain and Fear.

Results of the Regular Series

1. *Classical Music*

Figs. 1 and 2 are typical expressions for this situation as recorded by the ordinary camera. The subjects characterized their feelings during the situation as follows: Interest in the Melody (6 subjects noted this feeling); Indifference (6 subjects noted this feeling); Contemplation (1); Boredom (4); Abstraction (4). The subject illustrated in Fig. 1 described his feelings as boredom and abstraction; Fig. 2 as interest in the melody. In all the studies in this situation it will be noted that there is a general relaxation of the facial musculature which gives the expression which we generally term as abstraction. Darwin (5) speaks of abstraction as being marked by a vacant stare which is due to the relaxation of the eye muscles and to the wrinkling of the lower eyelid due to a partial contraction of the upper orbicularis oculis.

2. *Jazz Music*

Figs. 3 and 4 give typical expressions resulting from the listening to Jazz Music. The feelings caused by this stimulus

were described as follows: Rhythmical Feeling (12); Interest in the Melody (2); Boredom (3); Indifference (1). The subject illustrated in Fig. 3 described his feelings as 'Rhythmical feeling, wanting to dance;' Fig. 4, 'Rhythm, much pep.' As to the mechanism of the smile Darwin (4) notes: "By drawing backwards and upwards of the corners of the mouth, through the contraction of the zygomatic muscles and by the raising of the upper lip the cheeks are drawn upward. Wrinkles are thus formed under the eyes. The eyebrows are slightly lowered showing that the upper as well as the lower orbicularis contract at least to some degree." It would seem that the effect of jazz music was to produce a pleasurable rhythmical feeling which shows itself in an increased tonus of the facial muscles and as a smile. This holds true in the case of the subjects who liked jazz music. However, the reverse effect was true in several subjects who disliked jazz and had a fondness for classical themes.

3. *Paintings of Nude Figures*

Figs. 5, 6 and 31 show the facial expressions obtained by studying Georgione's 'Sleeping Venus' and Bouguereau's 'Birth of Venus.' The feelings aroused by the studying of these pictures were described by the subject as follows: Sex Appeal (11); Aesthetic Appreciation (7); Indifference (3); Interest in Art (3). Figs. 5 and 31 are marked by a smile while Fig. 6 might be termed a smirk or a self-satisfied smile. This latter is due to a combined action of the orbicularis oris which would purse the lips, the contraction of the risorius which would pull out the mouth horizontally and a slight contraction of the orbicularis oculi muscles producing the wrinkles under the eyes. The expression in any of these illustrations would probably be termed a 'pleased smile.'

4. *Pictures of Christ*

Figs. 7, 8 and 32 are typical expressions produced by the studying of Rubens' 'The Crucifixion' and 'The Trinite.' The feelings aroused by these studies were described by the subjects as follows: Pity (7); Religious Feeling (7); Interest

in Art (5); Aesthetic Appreciation (4); Awe (4); Disgust (2); and Indifference (2). The subject in Fig. 7 and 32 gave a verbal reaction of pity and religious feeling. Fig. 8 notes 'more disgust than anything.' A study of Fig. 8 as compared to Fig. 12, for instance, which was aroused by disgusting stimuli shows the truth of this reaction. The subject in Figs. 7 and 32 shows a slight tendency toward a frown. This, in part, is due to the contraction of the triangularis which would depress the corners of the mouth and in part to the contraction of the corrugator supercilli, which causes a contraction of the eyebrows and the appearance of vertical wrinkles on the forehead. Darwin (3) speaks of the corrugators as the 'grief muscles' since they are invariably contracted in crying and frowning. This tendency to a frown may well be explained as an expression of the element of grief which went to make up the feeling in this situation.

5. *Pictures of Direct Sex Appeal*

Figs. 9, 10, 33 and 34 show typical expressions resulting from the studying of a strip of pictures of direct sex appeal. The feeling described by the subjects as aroused by this situation are as follows: Disgust (9); Repulsion (5); Sex Appeal (4); Absurd and Grotesque (3). Fig. 9 described his reaction as one of disgust and Fig. 10 as sex appeal and absurd. There is very little difference between the expression in Fig. 5 and that in Fig. 10, except that the smile is slightly more pronounced in the former. Fig. 9 has many of the characteristics of disgust, as will be seen in the discussion of the next situation. The motion picture studies, Figs. 33 and 34, give the results which it was hoped would be obtained, that is, a contrast between the study of pictures essentially vulgar in nature and ones which were æsthetic in nature. There is a difference which is only noticeable with study. I think that this rather subtle change is due to a slight flaring of the nostrils and a slight raising of the upper lip in the case of the vulgar pictures. These two changes of expression become more marked in disgust and repulsion. I should say that the verbal reaction of disgust and repulsion was true, although not

so pronouncedly as the reports would indicate. The characteristic expression in this situation is marked by an element of close attention and the rather repressed smile which indicates the sex appeal, coupled with the slight element of disgust as is indicated by the flare of the nostrils.

6. *Disgust and Repulsion*

Figs. 11, 12 and 13 are expressions aroused by the studying of various illustrations in Jefferies and Maxwells' 'The Diseases of China' (11). The feelings aroused by these illustrations were described by the subjects as follows: Professional interest (6); Repulsion (5); Disgust (6); Horror (5); Pity (8); Fear (2). (The professional interest is due to the fact that a part of the subjects were pre-medical students.) It will be noted that these figures are all marked by the vertical wrinkles on the forehead, the partial closure of the eyes, the firm closure of the lips, the depression of the corners of the lips and a slight raising of the wings of the nose. The vertical wrinkles are caused by the contraction of the corrugator supercilii; the partial closure of the eyes to the contraction of the orbicularis oculi; the closure of the lips to the orbicularis oris; the depression of the corners of the mouth to the slight contraction of the triangularis and the widening of the nostrils to the contraction of the nasalis. The firm closure of the mouth is, according to Darwin (6), a mark of determination and decision, while a gaping mouth is characteristic of disgust. This closure of the mouth or opening of the mouth is probably due in part to the way in which the disgust is aroused; if it is caused by some object which has been taken into the mouth, the mouth is opened to eject it; if it is outside, the mouth is tightly closed to prevent its possible entrance. Whatever 'pity' might have been felt is covered in its expression by the more powerful feeling of disgust.

7. *Odors*

Figs. 35 and 36 represent the surprise effect of smelling ammonia. This situation was termed surprise by 16 subjects, fear by 2 and curiosity by 1. The action was so rapid as to

make it impossible to get the changing expression on any except a motion picture camera. The expression in Figs. 35 and 36 is not the one which is commonly termed surprise. It is rather of the nature of a protective reaction. There is first a partial closure of the eyes and a firm closure of the mouth, the raising and the flaring of the nostrils, a droop of the corners of the lips and a smooth forehead. This is followed by a partial tight-lipped smile and the elevation of the eyebrows. Fig. 36 shows the auxiliary protective reactions of 'ducking' the head and the throwing up of the arms to protect the face. Howell (10) notes that the stimulation of the sensory fibers of the trigeminal nerve within the nasal cavity by ammonia gas causes a reflex inhibition of respiration. The flaring of the nostrils caused by the contraction of the nasalis is probably a part of this mechanism.

8. *Frogs*

Figs. 14 and 37 represent the resulting expression from investigating, tactually, the bucket containing live frogs. Figs. 15 and 38 gave the expression caused by putting the hand into a jar of human brains. The feelings aroused by the frogs were described as Fear (7); Surprise (10); Repulsion (4); and Anxiety (1). This situation also gave a series of expressions best shown by the motion pictures. A study of Fig. 37 shows 'fearful anxiety' followed by realization and a smile. The anxiety is marked by a narrowing of the eyes, a slight opening of the lips and a general tenseness of expression. With the realization of the contents of the bucket comes a closing of the lips and a normal opening of the eyes. This then changes into what is termed the smile of relief.

Fig. 38 is an interesting study of disgust. The subject has placed his hand in a jar of brains, and then withdrawn his hand and is looking at it. There is a markedly 'disgusted' expression which is composed of the following elements, the firm closure of the mouth and the protrusion of the lips, the flaring of the nostrils and the contraction of the risoris and zygomatic muscles producing the crescent shaped wrinkles from the nose around the corners of the mouth. This expression passed away in a smile.

9. *Electric Shock*

Figs. 16, 17, 39 and 40 show the expression produced by receiving an electrical shock unexpectedly. This shock was described by the subjects as Surprise (12); Pain (11); Fear (7); Anger (5). For some reason the subject illustrated in Fig. 17 received an especially heavy shock, so intense that the expression here is undoubtedly one of extreme pain. Darwin (7) notes that fear is expressed by 'the eyes and mouth being widely opened and the eyebrows raised.' This opening of the mouth is due to the contraction of the platysma muscles. Darwin (8) explains this contraction as due either to the desire for more air or to an 'involuntary shudder.' It seems to me that this contraction of the platysma can be explained more satisfactorily as follows. With fright comes a momentary stoppage of respiration, a holding of the breath. Holding the breath demands a continued contraction of the intercostal muscles to keep the ribs elevated and the chest expanded. The platysma is attached at one end to the mandible and at the other to the fascia pectoralis. The pectoralis muscles cover the upper ribs and are contracted in active stoppage of breathing. All of this gives an added support to the intercostals. Briefly then, the contraction of the platysma may be explained by saying that it acts as an auxiliary support to the ribs in the act of 'holding the breath.'

The opening of the mouth may be noted in all of the illustrations given on this situation. However, instead of the eyes being widely opened and the eyebrows raised there is a contraction of the orbicularis oculi and of the corrugators causing a 'squinting' of the eyes and the vertical wrinkles between the eyebrows. Fig. 16 shows a contraction of the zygomaticus more than of the platysma, the effect being the elongation of the mouth. The third picture in Fig. 39 shows rather indistinctly the expression immediately after the current was turned off. The mouth is still open, but the eyes are opened naturally again. The last picture in Fig. 40 shows this same thing more clearly. Here, however, the mouth is rounded, 'O' shaped. The fourth picture in Fig. 39 shows an interesting anger expression. The direct gaze through

slightly closed eyelids, the straight, slightly opened lips and the general bodily tension go to make up this expression.

Results of the Check Series

As has been stated, this series was run through to see to what extent three subjects could voluntarily reproduce the expressions with which they reacted during the regular series. The subjects chosen were ones whose expressions had indicated some feeling or emotional disturbance during the regular series. Figs. 18 and 26 give the expressions when the subjects were told to register 'contemplation or abstraction.' This could be easily done as these pictures show when compared to Figs. 1 and 2. The general relaxation with the slight contraction of the corrugators may be noted. Figs. 23 and 27 show the expression when told to register 'pleasure and rhythmical feeling.' Again the registration was successful for the smile and the generally increased tension may be noted here as in Figs. 3 and 4. Fig. 19 is a typical expression when the subject was told to register 'sexual excitement or lust.' The contrast between Fig. 5 and Fig. 19 is quite interesting. In Fig. 5 the eyes are narrowed, the smile is broader and the head held more erect, a general 'cocky' attitude, while though Fig. 19 shows some of these features in no element are they so pronounced.

Figs. 20, 24 and 28 give the voluntary expression of 'religious feeling or awe.' The subjects in Figs. 20 and 28 give the traditional expression of the upturned face and the eyes gazing on high, together with the sober, calm countenance. The subject in Fig. 24 gives a close approximation of his expression in Fig. 7. The fact that only one of the three was able to give other than the accustomed beatific expression which is associated with devotion is an interesting point in the light of acquired expressions.

Figs. 21 and 29 are the record of the voluntary expression of 'disgust and repulsion.' These are quite successfully formed, the flare of the nostrils and the partial contraction of the upper lip are characteristic of disgust as has been previously discussed.

Figs. 22, 25, and 30 give the voluntary expressions of 'pain and fear.' Fig. 30 is especially interesting for as was stated the subject received a very painful shock in the regular series. When told to register pain he placed his hands on the electrodes as in the regular series and tried to imagine the situation again. The voluntary expression shows some opening of the mouth and narrowing of the eyes but in no such marked degree as in the regular series. Similarly Figs. 22 and 25 give expressions showing to an extent the facies of pain but not so intense as that produced by the electric shock.

Variability

This study yields a point on the variability of expressive reactions which should be followed up by further experimentation. In the regular series the pictures of the subjects in most situations showed a marked variation. In the cases where the expression was the traditional or expected expression I have made use of it in this analysis. Many of the subjects, however, gave little or no expression and many gave expressions widely different from the traditional expression. This indicates that the concept that each emotional pattern has a set form of expression is open to doubt. Again, when in the check series we find that the subjects so frequently gave the traditional expression rather than the expression that they gave in the situation itself we have further indication of this variation. Although the experiment was not designed to cover the point, it seems to show that the idea which is back of the experiments of Langfeld (12), of Feleky (9) and of Ruckmich (15) is open to question. These experimenters have taken posed pictures where the facial expression was the traditional one and then rated a person's ability in the judging of expression or character by his judgment of the emotion which he thought the picture showed. If the indications of the present study are correct what a subject is really doing in judging a portrait is reacting on the basis of former experience with illustrations, portraits, and the like which have had labels attached naming the emotion and not to any similarity of portrayed expression to expression in actual life. This point is an open one which awaits more conclusive evidence.

Theoretical Considerations

As has been discussed in the introduction the study of faces and the meaning of facial expressions is almost as old as the race. There are general observations which everyone makes, we say he has a good-natured face, or a mean look, correlating certain types of behavior with certain general facial expressions or anatomical make-up. Ask the ordinary man how he makes these judgments, on what particular characteristic features or motions and the chances are that his answers will be very vague and generalized. That is, he can make the judgment, but he has never analyzed out on what this judgment is based. The physiognomists tried to make such analyses. They endeavored to correlate certain anatomical formations with certain types of temperament, basing their entire assumption on static expressions due to the facial formation. To quote Lavater (14) "Calm reason is certainly not expressed from this profile. The forehead pressing forward, the strongly arched nose, the projecting chin, the eager look expressed in the straight outlines of the upper lids, all leave us not a moment in doubt that this is a person of ardent, rapid, anticipating, hasty character. All of which is discovered, not by motion, but by the firm parts or by the flexible in a state of rest." It seems to me that it was by just such reasoning that the physiognomists failed to achieve their hope of a permanent science, that is, they tried to correlate character with static features. We really judge character and emotion chiefly by the features in motion, by the play of expression, by the changing high-lights and shadows brought about by the various muscular contractions and not, ordinarily, by any static pose.

It is from such a basis that I wish to consider facial expression and its relation to character. Based on Darwin's work we may say that facial expression does not hold constant among all races in so far as one expression expresses one emotion. The indications seem to be, as mentioned above, that there is a great individual variation of expression from subject to subject. The traditional mode of expression likewise very probably changes from generation to generation.

I have no direct proof for this last assumption but judging from the illustrations from books published in the eighteenth century, for instance Lavater (14), it would certainly seem that one rarely sees such expressions. This change in traditional expression has probably not been nearly so rapid as the change in popular language or in slang, but may be compared to the very gradual change such body of language undergoes during time. Just as the compilation of dictionaries and grammars may be said to have slowed down the changes in language so it may be entirely possible and probable that motion pictures will go far to fix and conventionalize the facial expressions of the world at large.

Darwin attempted to treat all expressions philogenetically, to show how each is a product of adaptive evolution. That this is true for the expressions accompanying primary emotions and reaction tendencies such as fear, rage, laughter, crying, disgust and possibly surprise, seems to be born out by anthropological studies among different races at different times. However, the more subtle expressions such as devotion, affection, scorn, innocence, etc., would certainly seem to be acquired through imitation, social environment, if you please, since certainly they do not hold constant even from individual to individual in the same community at the same time. There is in any emotional situation or in any situation in which we wish to convey knowledge to another a discharge of nervous flux. In infancy this flux is distributed to all muscles and the baby responds with many sorts of contortions which serve to release this energy. With growth and social training this 'squirming' is inhibited and the child is taught, mostly by imitation and indirect suggestion, to give expression by the subtler forms of expression. Other facies are the result of direct physiological conditions. For instance, when the body is relaxed, as in sleep, or in pensiveness there is a relaxation of facial muscles as well and an expression spoken of as pensive or sleepy, results. Again with increased bodily tension as in anxiety or anticipation there is an increased tonus of the facial muscles and we speak of the tense expression or the anxious smile.

It might be noted here that when, during this experiment the experimenter came into the room with the subject, facial expressions at once became more marked, and to use the common phrase, there was more light and life in the face.

Taking up the various expressions which were obtained in this experiment, we find that the expression which we call 'contemplative' or 'abstracted' resulted when most of the subjects sat passively listening to the classical music. This was due mostly to general relaxation. The melody did not interest or gain the attention of most of the subjects and hence in the absence of any stimuli commanding attention there was a general relaxation. The expression of pleasure which most of the subjects gave with jazz music was due in part to the irregularity of the rhythm and in part to the simple, easily comprehended melody, both factors, which would go far to gain and hold attention. Further than this the piece was rather popular at the time and several of the subjects noted that it called up pleasurable memories.

The expression caused by studying pictures of the nude figures in Situation 3, might be accounted for by the fact that the close attention caused an increased tension of facial musculature. Coupled with this was the element of sex appeal which was expressed by the selfconscious smile. This smile is probably an acquired reaction substituted for more direct forms of expression.

The expression caused by studying of the pictures of Christ show sadness. This is due, most probably, to a feeling of unpleasantness brought on by the suffering represented in the pictures. The feeling of unpleasantness in slight amounts is correlated in most persons with a drop in blood pressure and a slight relaxation of the face, most marked by the drag of the platysma causing the droop of the corners of the mouth. If we consider unpleasantness as due to the inhibition and cancelling of nerve impulses then the relaxation follows through the loss of tonus.

The pictures of vulgar sex appeal brought on an expression which might be classed under McDougall's term 'fascination' since there is a combination of curiosity with disgust; disgust

at the utter vulgarity. This reaction was certainly based on training and development for the same pictures when shown to a man of little education and training, produced an expression of frank interest and delight which was not coupled with a flare of the nostrils. Unfortunately it was not possible to get this man to serve as a subject and so record the expression. The disgust and repulsion which are shown by the subjects looking at pictures of oriental diseases is a reaction modified from that primarily caused by substances offensive to the taste and sense of smell. The reaction is of a protective nature, the squinting of the eyes, puckering of the mouth and flaring of the nostrils all tend to prevent contact with the substance. The flaring of the nostrils goes to narrow the air passage higher up the nasal path and so eliminates as much of the odor as possible.

An expression such as is produced by the smelling of ammonia is rather a good example of an instinctive protective reaction. The same effect is produced as in primary disgust which was discussed above, namely tight closure of the mouth and eyes and partial stoppage of the nostrils. This is accompanied by other protective reactions such as throwing the head back, raising the arms, etc. The frogs proved to be very good stimuli to bring about a tense anxious expression as was discussed above. The general bodily tension, the slight overflow of nervous energy in the form of a tight-lipped smile or laugh and the general expression of strain are all characteristic of this physiological condition. The electric shock gave the facial expression of pain. The holding of the breath and the consequent opening of the mouth, the coördinated reaction of the entire body in getting away from the painful object; and then, this followed by the rounded lips and the opened eyes of surprise, are all well shown in Fig. 40. When the pain was coupled with anger, there comes the direct gaze and the straight tight lips after the pain has gone, as is shown in Fig. 39.

Summary

This experiment was designed for the purpose of analyzing facial expressions of a normal group of subjects under a set of

controlled conditions. The main interest was in the expressions which are traditionally associated with certain emotions so that only pictures showing these expressions were chosen for study. In a check series several subjects who were rather expressive in their reactions in the regular series were required to voluntarily express or 'register' the various emotions which had been aroused in the regular series. These studies show that in general attempts at voluntary reproductions of emotional expressions result in traditional expressions rather than those which are actually obtained in emotional situations. The following are the main points brought out in the regular series.

1. Classical music gave to the most of the subjects in this experiment a feeling of boredom and caused a relaxed expression. Jazz music gave a rhythmical feeling and caused in most of them a smiling, attentive expression.

2. Paintings of nudes caused a smile and close attention. Pictures of direct sex appeal gave rise to complex expression showing interest, sex appeal and disgust.

3. Paintings of the crucifixion bring an expression of pity and sadness.

4. Expressions of disgust and repulsion may be analyzed into the following elements: firm closure of the lips, squinting of the eyes, vertical wrinkles at the base of the nose and the flare of the nostrils.

5. General anxiety is expressed by a rather fixed stare, a slight frown and an increase of bodily tension.

6. Pain is expressed by the partial closure of the eyes, the fall of the lower jaw, and the contraction or partial contraction of many other facial muscles. The fall of the jaw, due to the contraction of the platysma muscles, is a part of the mechanism of "holding the breath."

7. Expressions of contemplation, pleasure, sex feeling, and disgust can be readily produced by untrained individuals. The expression of religious feeling is rather difficult to form voluntarily. The expression of pain cannot be voluntarily produced in anything like so intense a manner as an actual stimulus will produce.

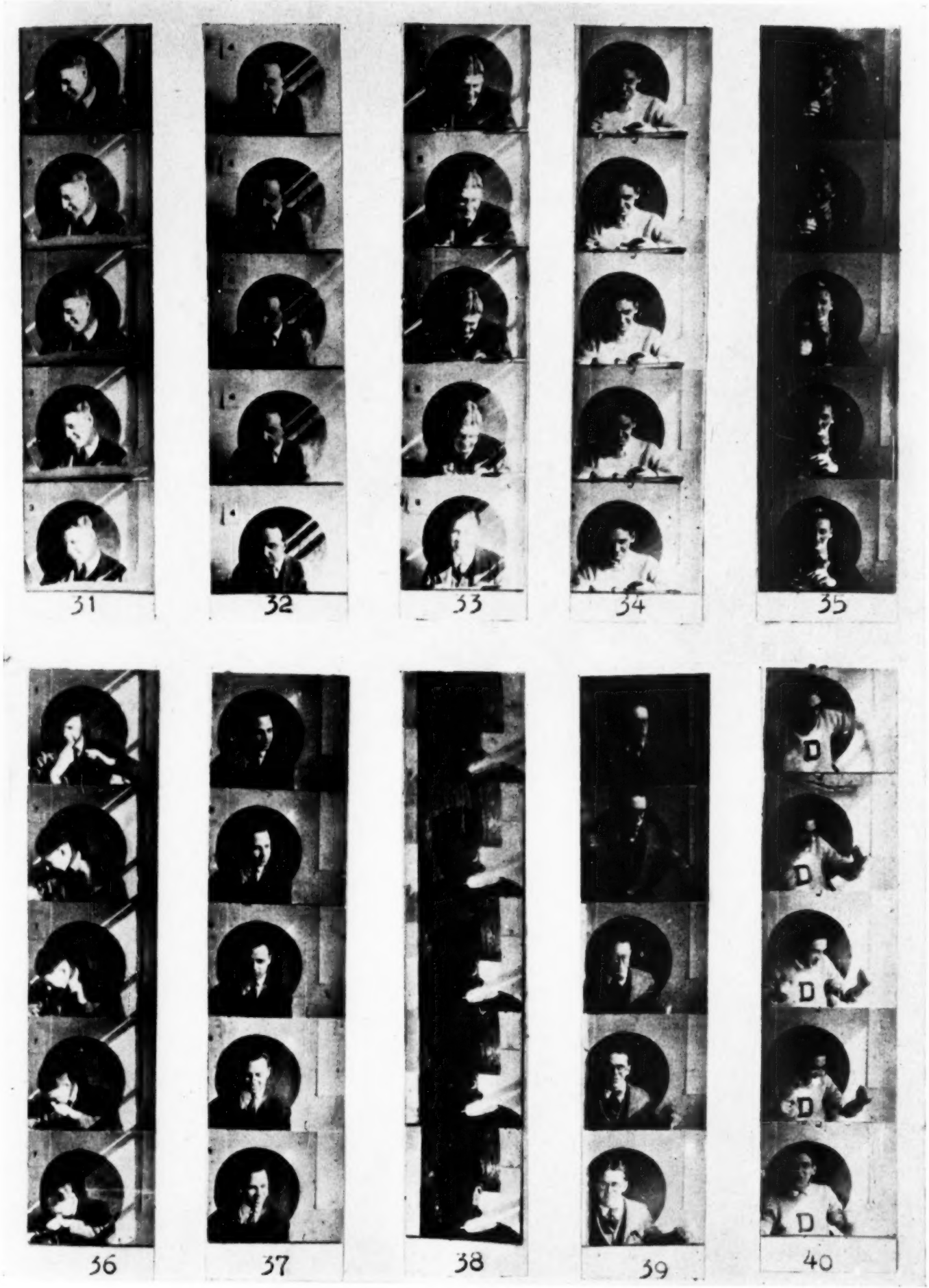
PLATE I.

Studies of Emotional Reactions.

PLATE II.

Studies of Emotional Reactions.

PLATE III.



Studies of Emotional Reactions.

8. The study suggests that in many cases the actual situation gives rise to a wide range of expressions and that the correlation between any given facial expression and a standard situation would be low.

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COMPLEX SIGNS IN DIAGNOSTIC FREE ASSOCIATION [1]

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I

Perseveration of Complex Signs

It has long been believed that there is a tendency towards perseveration of complex indicators in free association, *i.e.*, that the emotion accompanying a given stimulus word in the free association list will be carried over from that word to the next and possibly even farther. In the series of reports made by Jung and his associates the presence of a tendency towards perseveration of complex signs is frequently asserted. Jung says: "The perseveration of the emotional tone deserves attention. Perseveration plays, as we know, a peculiarly large share in the pathology of the association process. Perhaps the investigations on normals have helped to elucidate the essential problem of morbid perseveration." [2]

Jung has recognized two types of perseveration. The first where the response to a stimulus word affects the nature of the response to the next stimulus word. This might be called the perseveration of the idea. An example of this type is cited by Jung where a subject responded to the stimulus word 'long' by giving the word 'big.' When the subject was given the next stimulus word which was 'ship' he also responded with the word 'big.' In this case, he says the idea has persisted and the subject has reacted to the preceding idea rather than to the new stimulus word.[3]

[1] This is the second of a series of Wisconsin studies in diagnostic free association. The first one appeared in this JOURNAL, Vol. IV., p. 111 ff.

The writer wishes to express her thanks to Professor Clark L. Hull for suggesting the subject and technique of this investigation and for his assistance in the preparation of the manuscript.

[2] Jung, C. G., 'Studies in Word Association,' p. 258.

[3] Jung, *op. cit.*, p. 248.

The second type of perseveration is where there is a complex sign accompanying the response to a given stimulus word and the same complex sign accompanies the response to the next stimulus word. Jung paid particular attention to the perseveration of long reaction-times, though the problem is evidently very much larger than this one indicator. If there is an appreciable perseveration of the emotion, it ought to be shown by any other of the alleged complex signs, such as failure to reproduce, laughing, rhyming, word completion, etc. Jung cites some cases which he believes show the tendency very clearly. In one instance the length of reaction-time for the word 'right' was 7.6 seconds. The next word which was 'people' had a reaction-time of six seconds. The word 'small' followed this with a reaction-time of 4.8 seconds. The next five words showed a gradually decreasing reaction-time. This, according to Jung, shows a rather severe complex disturbance which began at the stimulus word 'right' and gradually decreased in the seven reactions that followed.[1] Unfortunately, Jung does not produce sufficient evidence to show conclusively that there is a real tendency for perseveration to take place since, after all, isolated examples do not constitute scientific proof.

If there is a tendency towards perseveration how can its presence be shown and how can its extent be measured? In the first place it is assumed that if this tendency exists then complex signs must be followed by complex signs. But in the case of any given sequence of complex signs, how can we be sure that the sequences of complex signs which seem to be due to perseveration are not in reality due to the fact that all the stimulus words in the sequence themselves touch complexes? Since the experiences of different persons differ so widely, a word which is not an emotional word for one person may easily arouse an emotion in another person and vice versa. It is accordingly impossible for anyone to state in any given case whether the stimulus word has touched a complex or not. It is also quite evident that by pure chance there will sometimes appear sequences of genuine complex words, of various

[1] Jung, *op. cit.*, pp. 304–305.

lengths. The question of whether or not perseveration exists accordingly hinges on whether or not there is more of this tendency to sequence of complex signs than would be produced by pure chance. In other words, if we first determine how extensively sequences would take place by pure chance, then any considerable excess found beyond this may be attributed to the perseveration tendency. If, on the other hand, there should turn out to be no such excess beyond chance, then we must conclude that perseveration probably does not take place.

In order to insure that no constant error with respect to sequences of complex signs should enter the results because of the accidental arrangement of complex words in the stimulus series, the stimulus words for the present study were arranged in fifty different orders each according to chance. The fifty lists were made up as follows: Each word of Jung's association list was written on a small circular piece of cardboard and placed in a box. The experimenter then shook the box until the disks were thoroughly mixed and drew them out one at a time by pure chance. The words were typewritten in the order in which they were drawn. So far as the writer has been able to discover, this is the first time that the technique of giving the stimulus words in continually varying orders has been employed. It may also be noted that in addition to permitting the determination of the strength of the perseveration tendency, this technique also enables us to determine quantitatively the strength of the tendency of complex signs to vary as a function of the position in the stimulus series. (See Part II.)

One hundred people, fifty men and fifty women, were chosen to act as subjects in the experiment so as to avoid any constant error due to sex. The people were all students at the University of Wisconsin. The experiment was not always conducted in the same room, but care was taken to select a quiet place away from everything which might prove distracting to the subject.

Each subject was given the following instructions: "I am going to say a list of words to you, and after each word I want

you to say the very first word you think of regardless of what it may be. For example, if I say 'dog' and the first word that comes to your mind is 'cat' you say it just as quickly as it comes to your mind." The subject was given a trial word to make sure that he understood what was wanted of him. The experimenter then went through the list of words using Mueller's special blank for this purpose.[1]

The blank is so arranged that each of the complex indicators may be recorded by simply placing a check in the proper column opposite the stimulus word. The speed with which this may be done enables the experimenter to be very accurate in observing the subject and recording the indicators. The time between each stimulus word and its response was recorded with a fifth-second stop-watch. After the list had been gone over once the examiner said to the subject, "I am going to say these same words to you again and I want you to try to give the same response each time that you gave the first time. If you do not remember what you said the first time, simply say that you do not remember, but if you think you remember the response, say it. You may have as much time as you wish to think of the word."

The following alleged complex signs were thus recorded:

1. No response. In some cases the subjects are unable to give any response at all to the stimulus word.
2. Failure to reproduce, which includes: *a*. Inability to give any response the second time the list is gone over.
   b. Failure to recognize the stimulus word at the second presentation.
   c. Giving a different response on the second trial from that given at the first presentation.
3. Reaction word having no apparent relation to the stimulus word.
4. Word completion, such as 'sadness' in response to the word 'sad.'

[1] This blank was devised by Mr. Mueller in an extensive investigation not yet ready for publication. The writer wishes to express her thanks for the privilege of using this convenient form.

5. Repetition of the stimulus word. The subjects sometimes repeated the stimulus word before giving a response.
6. Laughing and smiling.
7. Talking about the stimulus word or the response.
8. Long reaction-times. Thirteen fifths of a second or more is considered a long reaction-time.

It was the original plan of the experimenter to use all of these complex indicators but there were too few cases of some indicators to make the results reliable so only laughing and smiling, long reaction-times, and failure to reproduce were used in the final computations.

The present investigation was concerned only with the second type of perseveration mentioned above. The purpose at the outset was to determine whether or not such a perseveration really exists, and if it exists, how strong the tendency is immediately, and what changes take place in the strength of the tendency with the lapse of time after the critical response. This problem was suggested by Hull and Lugoff in 1921. They say: ". . . we may consider a single detail like the alleged perseveration tendency of which Jung makes so much. Does it really exist apart from accidental succession of long reaction-times, say, and if so how strong is it? Does it exist in the case of all the complex signs or only for some? Is it equally strong for all signs where it operates at all, or does it vary, say, according to their respective diagnostic strength? How long and how far in the series does it persist, and is the curve one of positive or of negative acceleration?" [1]

The method of computation used may be illustrated by the results on the first post-critical reaction for laughing. The results were first classified as follows, according to the well known principle of the four-fold table.

This correlation shows that if a person laughed when he responded to one stimulus word there was a slight, but real tendency for this laughter to reappear on the next word. This, of course, could easily be anticipated from ordinary observation. We have here, then, a certain quantitative

[1] Hull, C. L., and Lugoff, L. S., *op. cit.*, p. 112.

TABLE I

	Number of reactions *followed* by reactions accompanied by laughter	Number of reactions *followed* by reactions not accompanied by laughter
Number of reactions accompanied by laughter	*a*	*b*
Number of reactions not accompanied by laughter.	*c*	*d*

r_t = the degree of correlation,

$$r_t = \text{cosine} \frac{\sqrt{bc}}{\sqrt{ad}\,\sqrt{bc}} 180°,$$

$ad = 21533,$

$bc = 16033,$[1]

[1] The *ad*'s and the *bc*'s of each subject were multiplied before being combined into the totals shown above. It may be demonstrated very easily that gross spurious correlations may result if the *a*'s, *b*'s, *c*'s and *d*'s of the respective subjects are added or averaged before the multiplication is performed.

$$r_t = \cos \frac{\sqrt{16033}}{\sqrt{21533} + \sqrt{16033}} 180° = \frac{126.621}{146.748 + 126.621} 180°,$$

$r_t = \cos 83° 20' = +.12,$

$P.E_{r_t} = .011.$

index of the strength of the tendency. While it is undoubtedly true that the above method of computation yields a coefficient which has a close functional relation to the degree of perseveration, it also appears upon a little reflection that the present data do not conform to the chance relations assumed by the table as a condition for zero correlation. In order to obtain an empirical base line from which to evaluate the coefficient under the present conditions, the experimenter computed a correlation from the equivalent of the reactions for one hundred subjects arranged in a purely chance order. This was done by taking one hundred small wooden disks, nineteen of which were red and the remaining eighty-one white. One hundred chance arrangements, the equivalent of a total of nearly 10,000 reactions, were made from these, varying the number of red disks used for each drawing according to the frequency of the probability integral.[1] The

[1] There were not quite 10,000 cases because the number of reactions of a post-critical nature is less than 100 for each subject according to how far the post-critical reaction is removed from the critical one.

red disks were considered as complex signs, while the white ones were considered as non-complex signs. A correlation was then computed exactly as with the real reactions. The correlation obtained was −.071. This shows that according to this method of computation pure chance yields a small negative value. From certain mathematical considerations it appears that this negative value varies somewhat with the length of the series and other conditions, and that the value secured from the drawings is somewhat too high. Accordingly the value .05 has been fixed upon as a satisfactory correction which must be added to the four-fold r. This gives us a value which may be called an index of perseveration and represented by the symbol I_p. The formula thus becomes:

$$I_p = .05 + \cos \frac{\sqrt{bc}}{\sqrt{ad} + \sqrt{bc}} 180°.$$

Accordingly the first post-critical perseveration index of laughing is .12 + .05 or + .17.

Similar counts were next made for each of the subjects for the second post-critical reaction on laughing, the third post-critical, fourth post-critical, and twenty-fifth post-critical reactions. To illustrate, the second post-critical classification was as follows: Suppose, for example, that the subject laughs at the stimulus word 'ridicule.' On the next word (first post-critical) which is 'window' he may or may not laugh, but with the word 'friend' which follows this (second post-critical) he does laugh. Thus skipping or disregarding the first post-critical reaction in the above manner, all of the cases of laughter followed by laughter, laughter followed by no laughter, no laughter followed by laughter, and no laughter followed by no laughter were counted. The index of perseveration in this case was found to be + .077, showing that the tendency towards perseveration had decreased considerably. The results for the third, fourth, and twenty-fifth post-critical relations will be found in the following table:

Since there seemed to be such a strong tendency for the index of perseveration to drop considerably at each succeeding post-critical reaction, the experimenter skipped from the fourth to the twenty-fifth post-critical. The result of + .10 found there is probably due to an error in the computation,

TABLE II

Post-critical Distance	I_p for Laughing	I_p for Long Times	I_p for Failure to Reproduce
First	+ .17	+ .047	+ .10
Second	+ .077	+ .059	
Third	+ .013	+ .06	
Fourth	− .015	+ .052	
Fifth		+ .071	
Tenth		+ .023	
Fifteenth		+ .068	
Twenty-fifth	+ .10	− .009	

although no error could be found when the results were checked. It does not seem probable that there would be any real tendency towards perseveration on a reaction so far removed from the critical reaction. A curve illustrating the decrease in the perseveration tendency of laughing is shown in Fig. 1.

The results on long reaction-times in the experiments were treated in the same manner as the results on laughing except that more computations were made. The results are given in Table II. The index in each case is very low and shows that the tendency towards perseveration of long reaction-times, while probably real, is very weak—indeed no more than a trace.

The experimenter noticed a great many times during the experiments that if it took a long time for a subject to respond to one stimulus word he often showed a tendency to hasten the reaction on the next one. When later, the purpose of the experiment was explained to the subjects, a number of them remarked that when they noticed it took a long time to react to one word they tried to react to the next one more quickly. This would probably tend to overcome the tendency to perseveration even if it existed.

The perseveration tendency of the complex sign, failure to reproduce, *i.e.* failure to give the same response the second time the words were presented, was also investigated. Only the first post-critical index was computed since the results on the other indicators proved to be so small. For similar

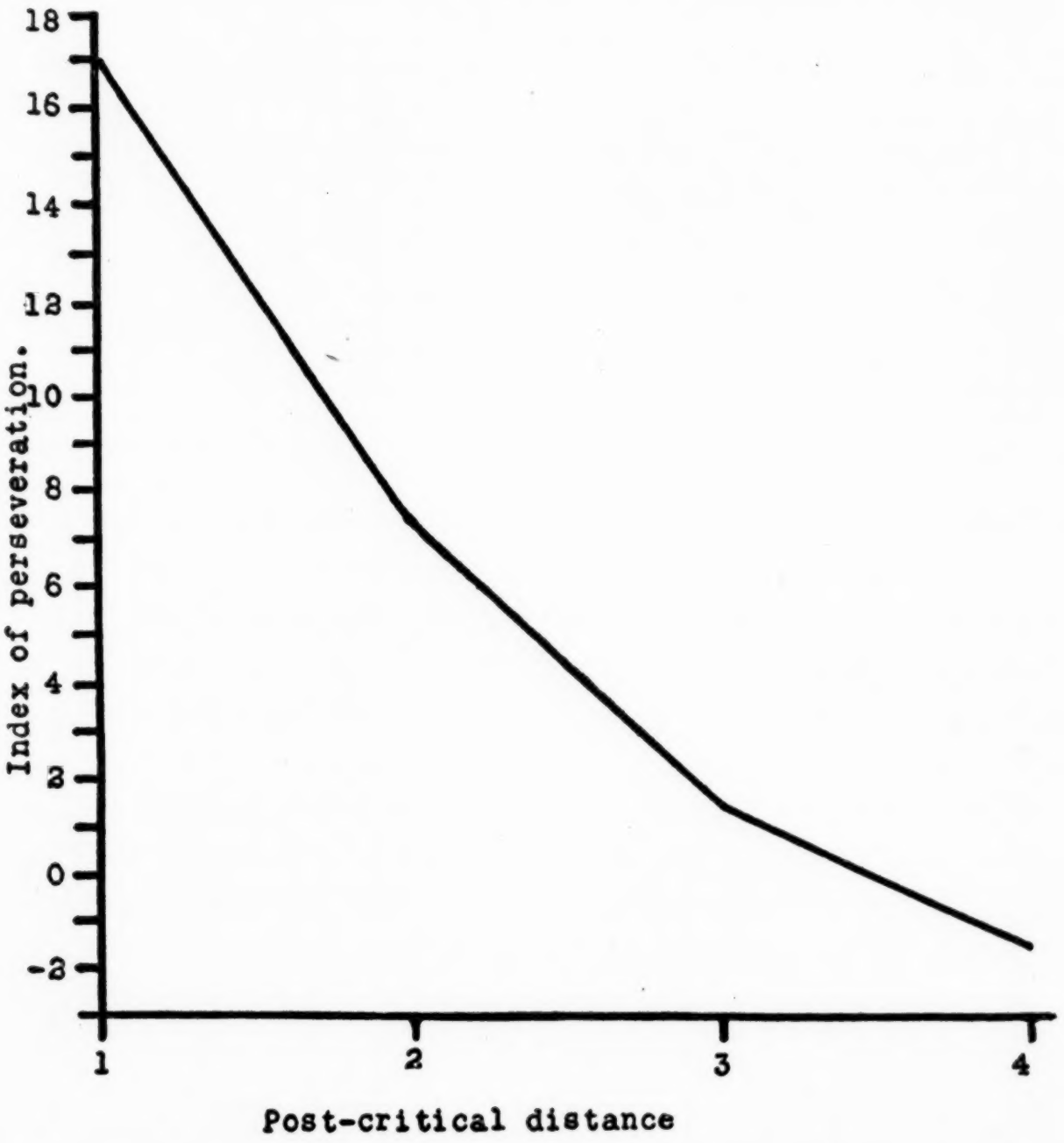

FIG. 1. The diminution of the perseveration tendency in laughing with the lapse of time.

reasons numerous problems suggested by Hull and Lugoff were not investigated though the data secured would have been adequate.

From the computations it would seem that the perseveration tendency of complex signs is too small to be of much value for diagnostic purposes, at least with normal sub-

jects. The failure of the signs to perseverate to any considerable degree also tends to cast some doubt upon the reliability of these signs as indicators of emotion.

II

The Frequency of the Appearance of Complex Signs as a Function of the Position in the Stimulus Series

This part of the investigation is concerned with determining quantitatively the strength of the tendency of complex signs to vary as a function of the position in the stimulus series. For example, at what place in the stimulus series is there the greatest tendency towards laughter, long reaction-times, failure to reproduce, and individual reactions?

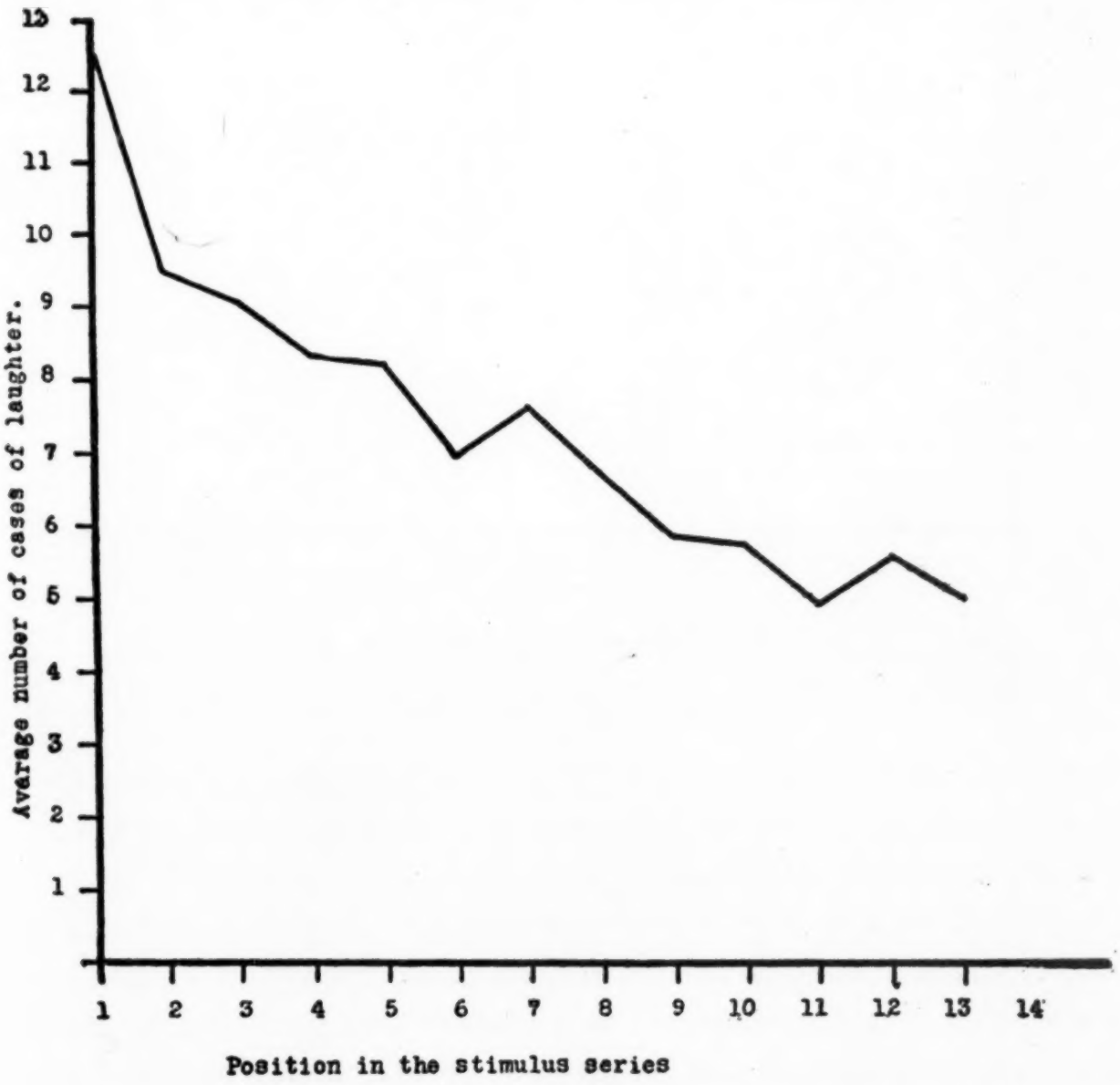

FIG. 2. Laughing as a function of the position in the stimulus series.

In order to find at what position in the series there was the greatest tendency towards laughter, a table was made of the 10,000 reactions according to position, from which it was possible to determine the number of persons who laughed on the first stimulus word in the series, the number who laughed on the second stimulus word, etc., through the entire list of one

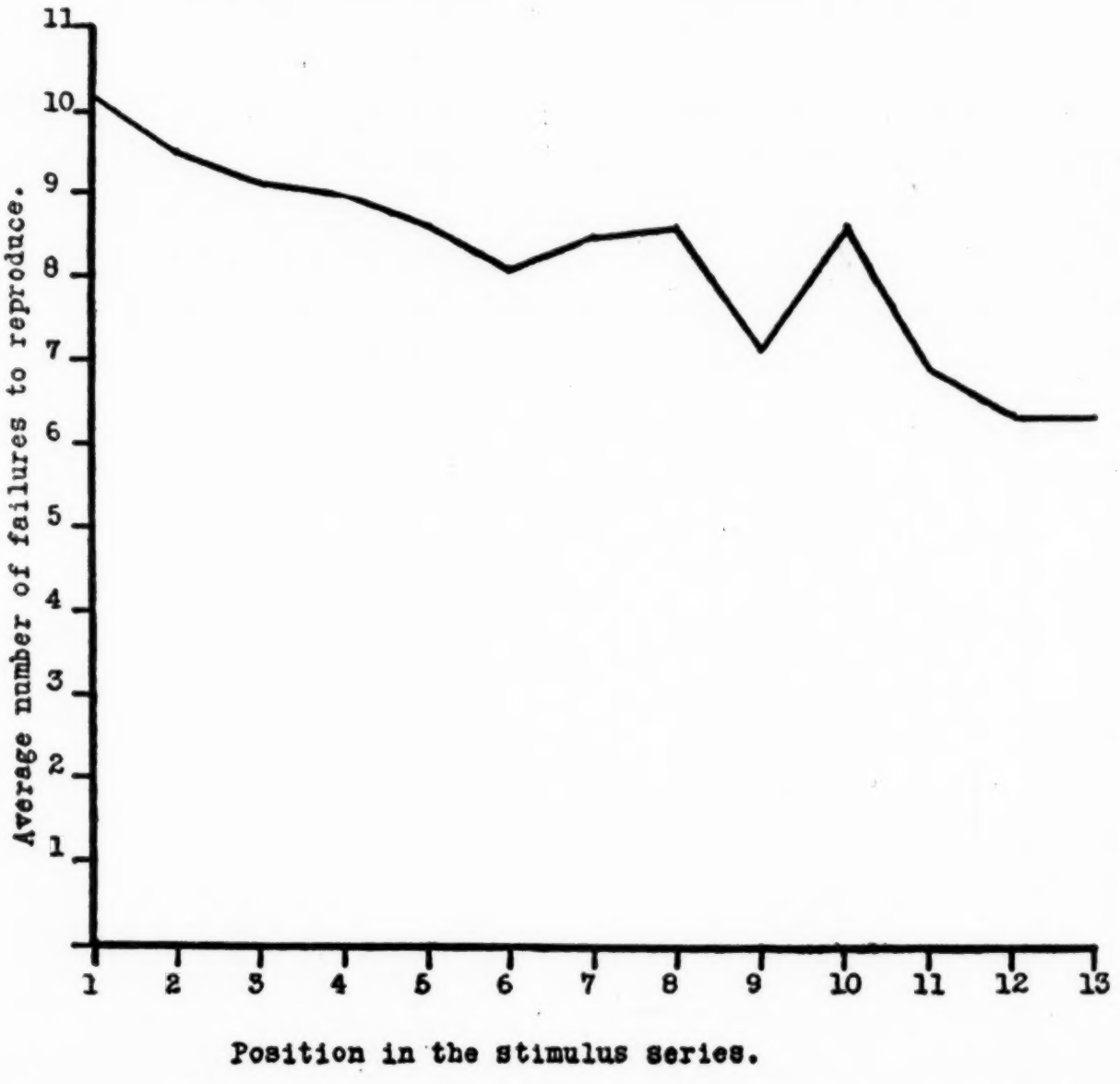

FIG. 3. Failure to reproduce as a function of the position in the stimulus series.

hundred words. The words were then divided into groups of eight words each and the average of each group was computed. These averages represent the number of cases of laughter accompanying each group of words and represent 800 reactions each. The averages were then plotted, as appears in Fig. 2. From this curve we see that there is the greatest tendency towards laughter at the beginning of the series and a steady decrease in the amount from the beginning to the end of the

series. Indeed the beginning of the series is over twice as likely to evoke laughter as the end. Since there is this special tendency towards laughter at the beginning of the series, it is quite evident that laughter at the end of the series is much more important as an emotional indicator than laughter at or near the beginning of the series. This matter seems never to have been investigated before. Indeed it has apparently been

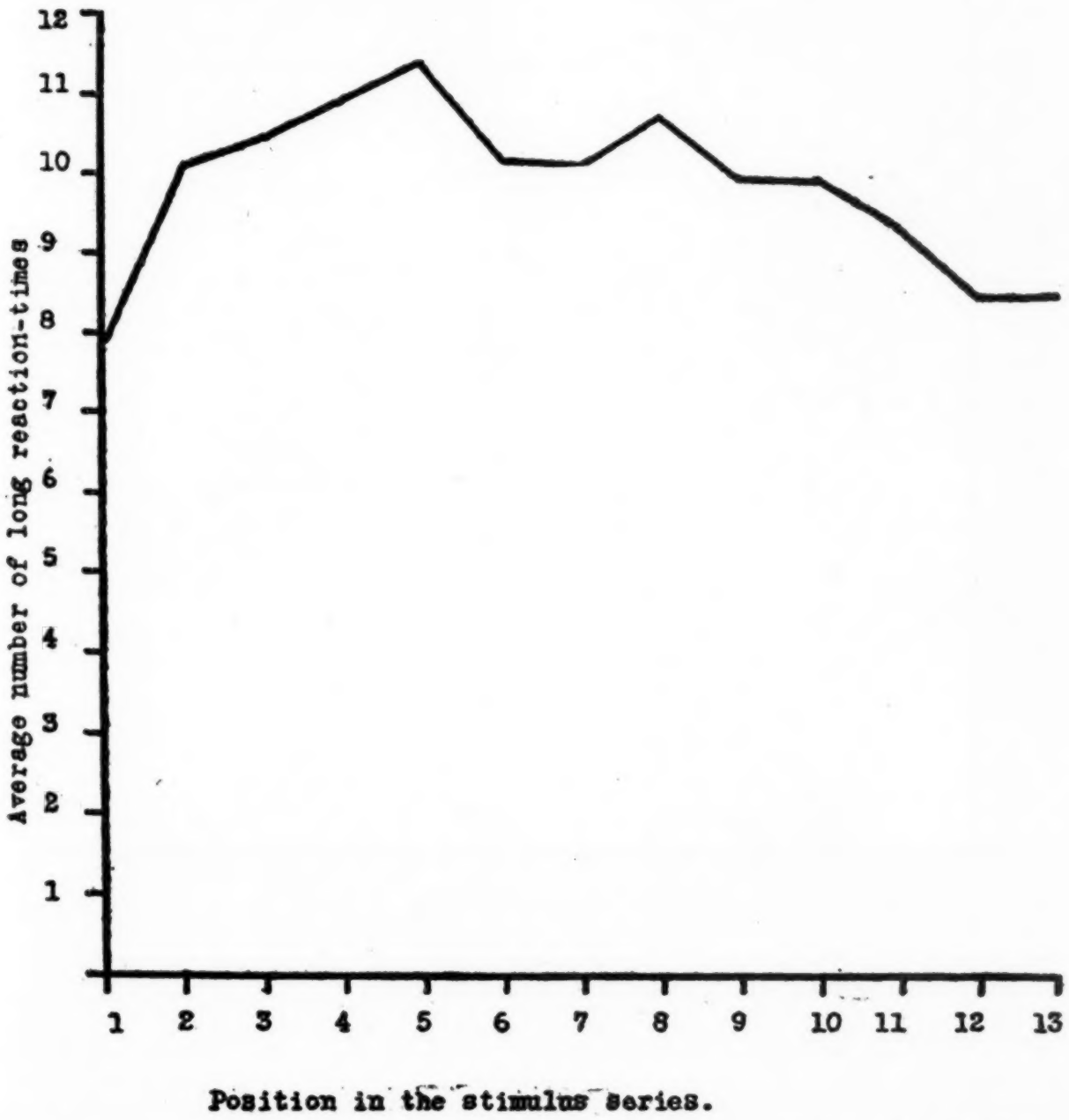

FIG. 4. Number of long reactions as a function of the position in the stimulus.

assumed that the complex indicators had the same importance regardless of whether they appeared at the beginning or the end of the series. It should be especially noted that since the words were reacted to in fifty different orders the results found above could not possibly have been produced by any peculiarity in the position of the words in the stimulus series.

The same procedure was employed to investigate the frequency of the appearance of the failure to reproduce, as a function of the position in the stimulus series. The curve of these averages (Fig. 3) reveals the same tendency as that of laughing although not to such a marked degree. This means that the words at the beginning of the series are not forgotten

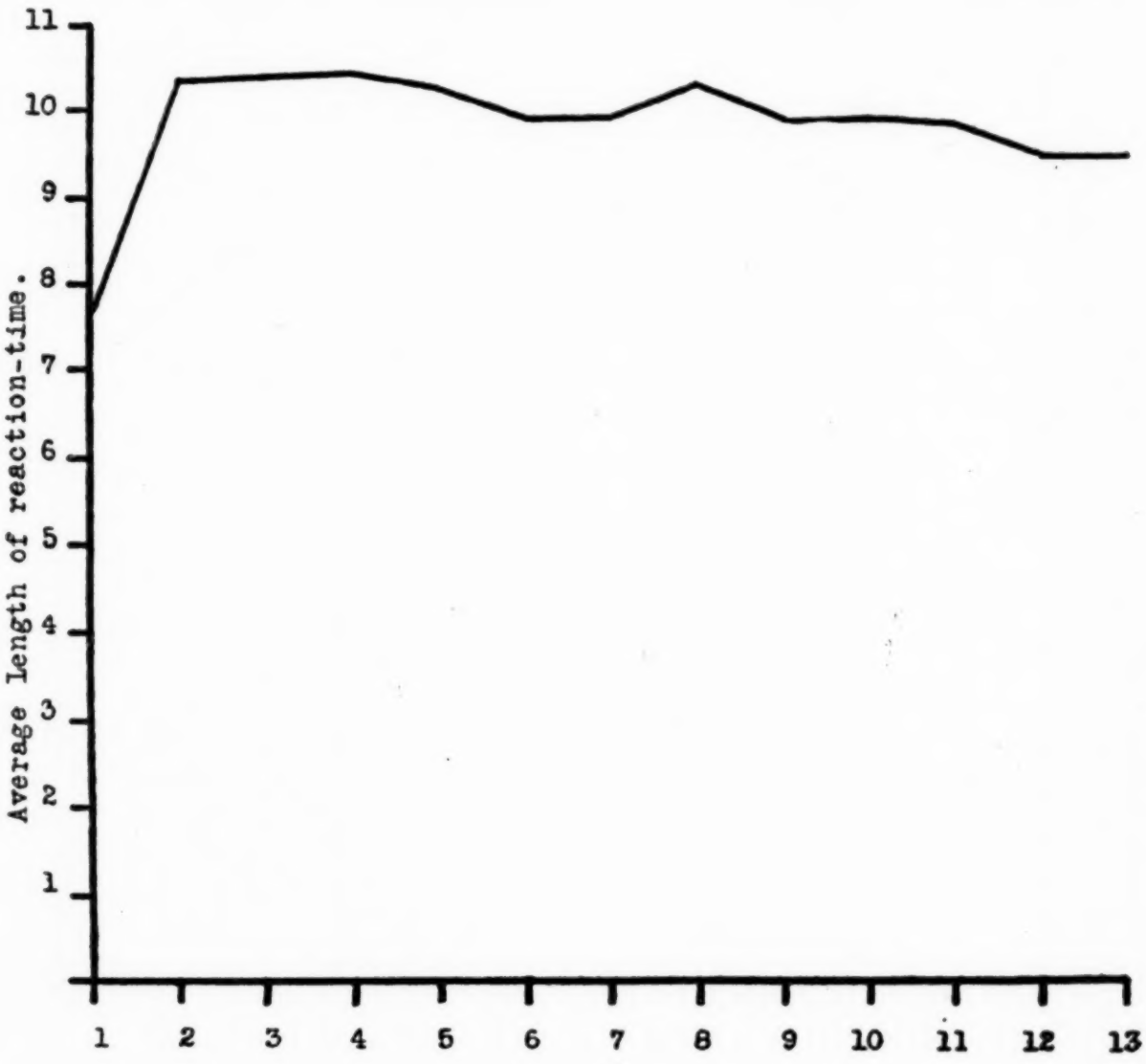

FIG. 5. Average length of reaction-time as a function of the position in the stimulus series.

necessarily because they are complex words but to a very considerable extent because of the position which they occupy in the stimulus series.

The results on the number of long reaction-times appearing with each of the groups of words was next computed in the same manner. The resulting curve (Fig. 4), shows a very different tendency from the two previously considered. The

greatest number of long reaction-times do not appear at the beginning of the series. In fact the number of long reaction-times at the beginning is less than at any other place in the

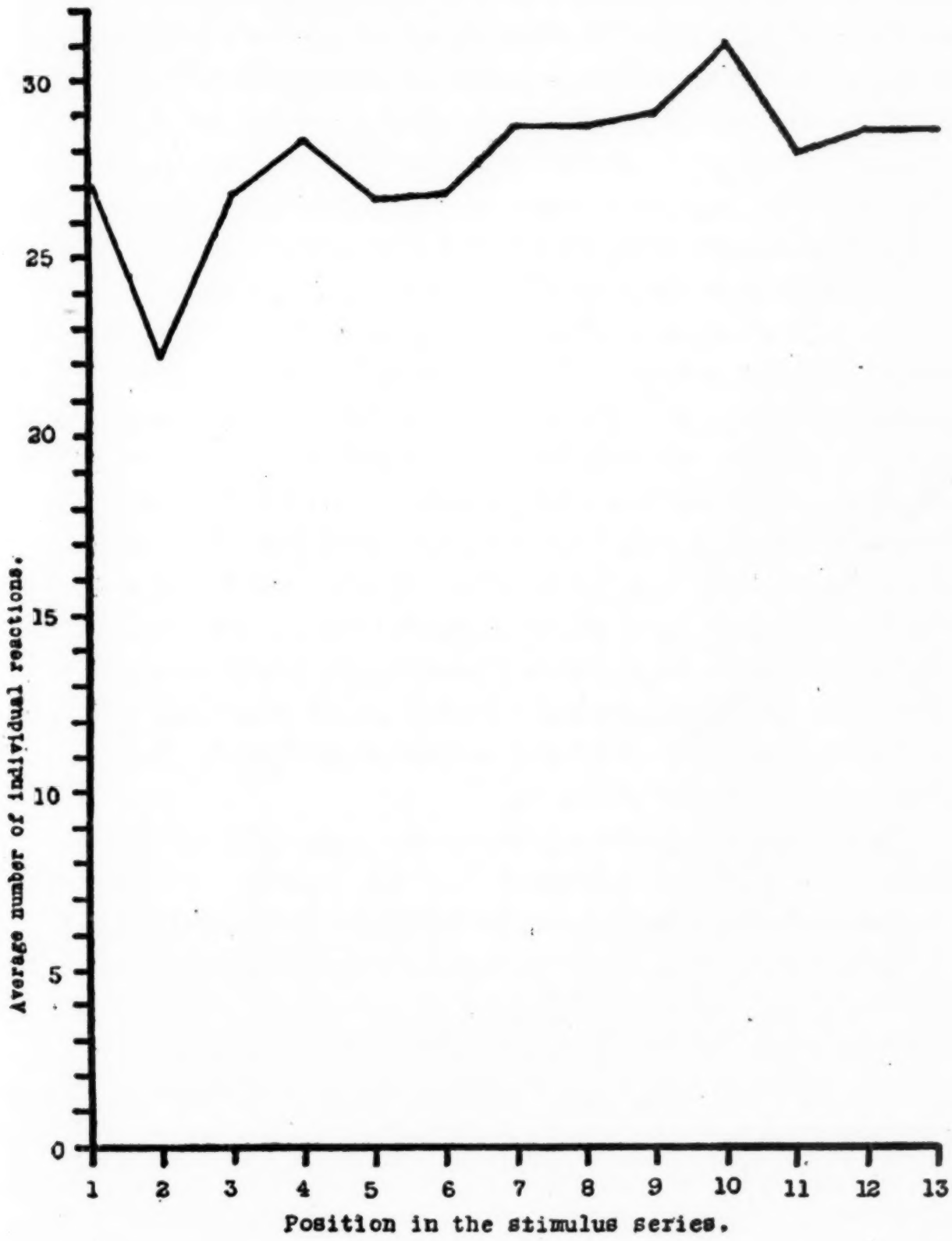

FIG. 6. Number of individual reactions as a function of the position in the stimulus series.

series. There is a steady rise in the number of long reaction-times from the beginning to the end of the first third of the

stimulus series and then a gradual decline in the number continuously to the end. Accordingly, long reaction-times at the beginning or end of the series are somewhat more significant as indicators than those appearing at the middle.

As a check on the results just given above a graph was also made showing the *average length* of the reaction-times for the different positions in the series. As might be anticipated, this curve (Fig. 5) shows practically the same tendency as Fig. 4. The reaction-times at the beginning are short and they grow longer towards the end of the first third and become shorter again as the end of the series is approached.

As a final step in the investigation the writer wished to determine the number of 'individual' responses given to the words according to their position in the series. Accordingly, a table similar to the Kent-Rosanoff frequency table was made showing the reactions given by all of the one hundred subjects for each stimulus word in the list.[1] The number of cases where only one person out of the one hundred gave a certain response to a given stimulus word, were recorded as individual reactions. From these data a curve was plotted to show the average number of individual reactions given for each group of eight stimulus words according to the position of the words in the series.

The curve representing these averages (Fig. 6) shows that there is a distinct tendency for the number of individual responses to increase gradually from the beginning to the end of the series. It is thus contrasted rather sharply with the tendency of laughing and failure to reproduce which tended to decrease from the beginning to the end of the series.

It is very evident from these results that the significance of a complex sign varies greatly according to the position which it occupies in the series and that the law of this variability may differ widely for different indicators. At the point of maximum frequency an indicator would appear (superficially at least) to be more sensitive in the sense that it requires less to touch it off. At the point of minimum frequency it would

[1] Kent, G. H. and Rosanoff, A. J., *American Journal of Insanity*, Vol. LXVII., Nos. 1 and 2.

appear to be less sensitive but for this reason more significant since the implication is that a stronger impulse is required to produce it. If the above conjecture turns out to be true, it seems likely that in later refinements of the association method, the various indicators should be weighted not only according to their general diagnostic potency but also according to the place in the series at which they appear.

A SPHYGMOGRAPH WITH AN ELECTRIC ATTACHMENT FOR RECORDING PULSE RATE AT A DISTANCE

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This article has as its purpose the presentation of a pulse recorder developed by the writer in the laboratory of Columbia University, together with a brief survey of the wide variety of methods which have been used and are being used in the study of the pulse. More than one worker in this field has announced the invention of a new and superior device, only to find that some other investigator has already described an appliance involving the same basic principle. The present writer, therefore, is chary of presenting this sphygmograph as new, but as far as revealed by a rather diligent search of the literature the underlying idea has not been used before.

The demand for this device arose in the course of a problem in which it was necessary to record the frequency of the pulse beat with the recording apparatus situated at a considerable distance from the subject. For a device designed to serve that purpose the following would seem to be desirable characteristics:

1. It should be easy to adjust to the subject.
   A. It should be readily adjustable to different people and should function efficiently on all types.
2. It should be capable of functioning over a long period of time without adjustment.
   A. It should not be permanently disturbed by movements of the subject, and disturbance caused by such movements should be as limited as possible.
3. It should be as comfortable as possible and allow the subject as much freedom of movement as possible.
   A. In general it should afford as little distraction to the subject as possible.

4. The record obtained from it should be clear and not ambiguous.

These are to be desired if the apparatus is designed only to serve as a means of making and breaking an electric circuit, thus affording a record of merely the number of the heart beats. If the apparatus is also designed to make a complete graphic record of the whole pulse curve, then the following characteristics must be added to the above list:

1. That it should be so constructed that its own inertia be reduced to a minimum, so as to afford the least possible distortion to the pulse curve.
2. That it should produce a clear-cut record of amplitude sufficient to make easy reading possible.

With the above demands in mind the author set about the construction of a device that would meet at least a majority of them. Since he was primarily interested in merely getting the number of heart beats recorded he was not so much influenced by the second group of requirements, though the apparatus as finally perfected meets all of the points fairly well.

It perhaps would be of value if the devices successively tried out and discarded as unsatisfactory could be enumerated here. The problem proved such a difficult one, however, that over a year has elapsed since the first models were constructed and in the meantime between twenty and thirty have been given up as impracticable, so that for economy of space no detailed account of the preliminary research work will be given. It will probably be sufficient to point out that there are two important sources of difficulty in constructing any device to meet the requirements set forth above. The first is that of attaching the mechanism to the pulse of the subject in such a way that it will not be disturbed by his movements or affected by changes in the blood pressure. The second is that the part of the device for making and breaking the circuit be sensitive enough to respond to every pulsation, yet steady enough not to be set in motion by every chance movement, changes in blood pressure, and so on. This last proved the most obstinate problem. It is relatively easy to transmit pulse movement into movement of a tambour or of a writing

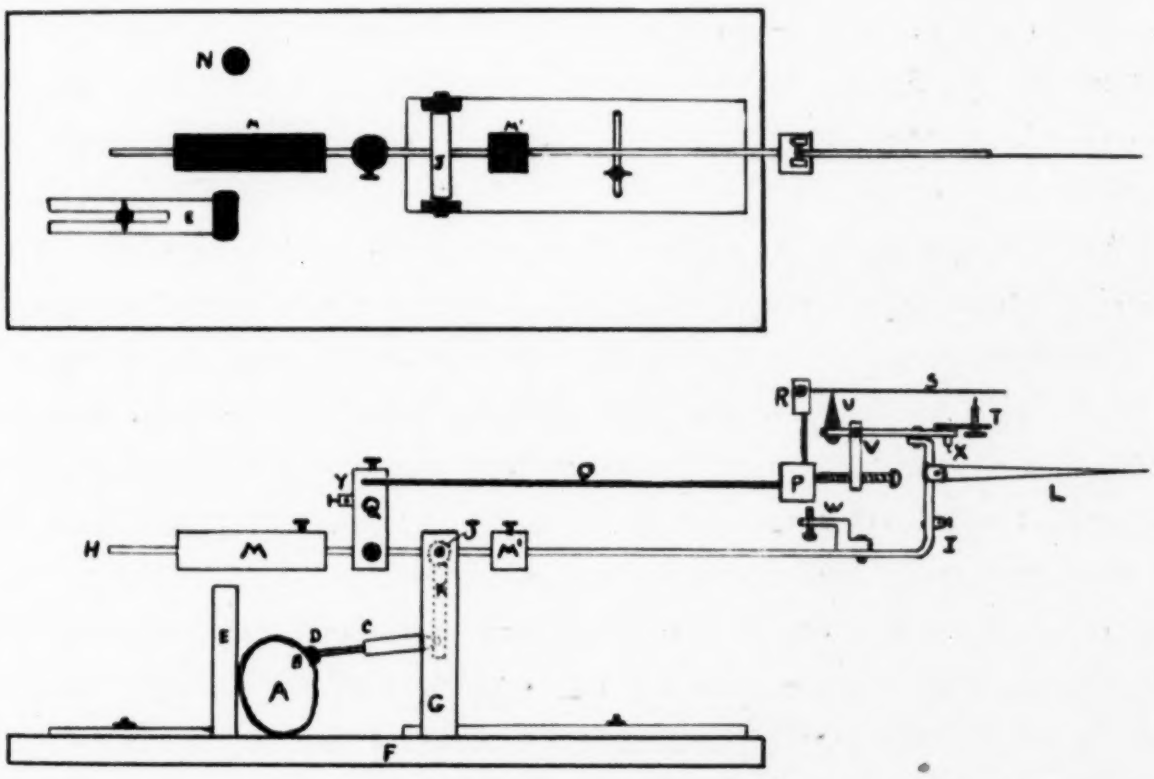
arm, though, as most who have worked with the common laboratory apparatus will testify, to achieve this over any long period and with all subjects is a real feat. But much harder is the problem of securing a sure and efficient make and break device. In the course of this investigation a dozen or more which seemed very promising turned out to have the fatal defect of being too sensitive to movements other than those of the pulse itself.

Dodge met this problem and solved it by a device which he reports as being fairly satisfactory, though he stressed the same difficulties reported above. The writer in the earlier course of his experimenting had not discovered Dodge's article but by chance he hit upon and developed somewhat the same idea. The essential parts of this method are a rubber bulb to be strapped over the radial pulse and carrying a rubber tube which is connected with a tambour upon which is mounted a lever which dips into a mercury drop or makes a contact with a platinum point. The same difficulties were found with this device as Dodge reports, namely that changes in blood pressure or in the position of the wrist of the subject tended to get the tambour contact device out of adjustment, in spite of various valves and airholes for keeping a constant air pressure inside the tambour. This scheme was therefore abandoned and attention directed to the search for some apparatus that would be more constant in its operation.

As the outcome of considerable further experimentation the apparatus shown in the accompanying diagrams was finally evolved. While at first view it seems rather complicated for the purpose, its complication was found necessary if it was to perform its function satisfactorily. It consists essentially of a balanced lever arm which is motivated by movement of the pulse and which carries a stylus for writing directly upon some moving surface, and also a device which is disturbed by the movements of the lever and thus makes and breaks an electric circuit, thus making possible the record at a distance.

Two views of the apparatus are shown. Fig. 1 represents a view from directly above, while Fig. 2 is a side view. An

understanding of the mechanism can perhaps best be gained from the second figure. In it a cross section of the left wrist is represented by the oval, *A*, with the pulse at *B*. Pressing against the pulse is an almond shaped button which is connected by a universal joint with the shaft, *C*. This arrangement allows the button to adapt itself to the position of the wrist. The shaft, *C*, is of two parts, one of which screws into the other, thus making it possible to lengthen or shorten the shaft to suit the demands of wrists of different thicknesses. The back of the wrist presses against a lug, *E*, which is fastened to the wooden base, *F*, by a set screw, so that it may be adjusted in such a way as to throw the wrist at the best angle to the rest of the apparatus.



FIGS. 1–2.

About four inches from the wrist are two upright supports, the nearer of which, *G*, is shown in the diagram, Fig. 2. They serve to support the long steel rod, *HI*, which is mounted on the shaft, *J*, which is housed in two simple bearings in *G* and *G'*. The rod *HI* is thus free to rotate around *J*, but other movement is precluded. Fastened into *J* and extending down between the two posts *G* and *G'* is a short rod, *K*, with a depression in it to receive the end of the shaft, *C*.

The operation of this device as a simple sphygmograph is then very easy to understand. The pulse causes the shaft, *C*, to move back and forth in a near-horizontal plane. Its movement is imparted to *K* and thus to the rod, *HI*, which thus rotates through a small arc, carrying the long stylus, *L*, up and down and recording either on a moving smoked paper, or, as will be shown presently, on a moving tape by means of an ink pen.

We may stop a moment to consider the advantages of the apparatus thus far described. The first and most immediate is its ease of application. The subject simply takes hold of an upright post, *N*, Fig. 1, rests his wrist against the stop, *E*, and the button of the shaft, *C*, is placed over the pulse and its other end is fitted into the hollow in *K*. The first time it usually takes a minute or two to adjust to the individual wrist and to find the best place to take the pulse. After that the whole thing can be put on or off in ten to fifteen seconds. A further advantage is that once in place it will stay in operation for an indefinite time, for no matter how much the subject moves his arm, as long as he holds fast to the post the weight of the lever arm, being adjusted as we shall show in a moment so that the greater weight is on the side *JI*, will cause the button to stay firmly against the wrist. It is for these reasons that the apparatus is especially adapted to experimental work in the undergraduate laboratory. It has been found in the Columbia laboratory that the types of pulse recorders now on the market are extremely hard to adjust and exasperatingly easy to get out of adjustment. It is for this reason that the present apparatus has found immediate favor in the regular classes in laboratory work, although not originally intended for this purpose.

A further feature that contributes to the efficiency of this instrument as a simple recording sphygmograph is the use of the two weights, *M* and *M'*, which allow any desired pressure to be put on the pulse. Some such pressure regulator is almost a necessity with any lever sphygmograph, for different wrists differ widely as to thickness and toughness of the superficial tissue overlying the pulse, and with ordinary laboratory

apparatus it is frequently found impossible to get any satisfactory record with extremely fleshy or muscular individuals. With the present device, however, it is possible to slide the weight, *M'* farther and farther along the rod, *JI*, until sufficient pressure is exerted.

One other factor should be mentioned. Since the whole apparatus can be so strongly made, considerable power is delivered at the writing point. This makes possible much less chance of a poor record. The whole writing device is infinitely less delicate than an ordinary tambour and stylus. It is so sturdy, in fact, that it is quite possible to mount an ordinary ink writer on the end of the pointer, *L*, and write directly upon white paper carried by a kymograph, as mentioned above. Specimens of records thus secured are shown in the accompanying illustrations.

These constitute the good points of the apparatus. There are some undesirable ones. The most important is that because of the inertia of the rather heavy weights—*M* and *M'* on the original model weigh over five hundred grams—there is considerable inertia in the machine, which probably results is a somewhat distorted curve. Likewise various pressures on the pulse will result in changing its shape. This objection, however, applies to every recorder that makes use of the pulse beat to move a lever, no matter in what form or how delicately. In the present case it would be possible to cut down inertia to a minimum by using light metals and cutting down the size of every working part. Another improvement would be the substitution of a pivot or knife-edge for the bearing at *J*. No change, however, will ever reduce friction and inertia to zero. This device should not, then, be credited with a sensitivity approaching that of the electrocardiographic methods of recording the heart-beat. A glance at the sample records will show that they approximate the sphygmograph records commonly presented in the text books and whatever distortion is present must be very slight. Certainly the record is sufficient for all ordinary experiments demanding sphygmographic technique. It is possible, moreover, by the use of a very long lever arm or by the substitution of some

similar device to produce records of much greater amplitude than those shown in the samples. Recent laboratory experiments have demonstrated that with certain modifications the apparatus is capable of producing records in which each wave has an amplitude of a half inch or more. To increase the record to this size occasions considerable distortion but if all is desired is a rough record the convenience of such a large picture is obvious.

So much, then, for this device as a simple sphygmograph. Used in such a way, all that are required are the base, *F*, the upright hand-hold, *N*, the stop, *E*, the uprights *G* and *G'*, and the rod, *HI*, with its shaft, *J*, and its extension, *K*, its weights *M* and *M'*, the pointer, *L*, and the shaft, *C*. For the purpose of making and breaking an electric circuit, however, some other parts must be added.

It has been indicated above that several devices to serve this purpose were tried out. It was evident that since with movements of the wrist the height of the pointer, *L*, would not always be the same, some sort of freely moving contact was needed. The one here presented serves rather well. Several features combine to make it as nearly satisfactory as any device of this kind can ever hope to be.

In principle it is simple, once understood. Mounted on the lever arm, *HI*, and moving with it is a weight on the end of the long flat spring, *O*. The one end of the spring is securely fastened in the brass block, *Q*, which is mounted on *HI*. The other end of the spring is fastened into the weight, *P*. *P*, except as will be shown, is free to move up and down, and once started in vibration will move up and down for a considerable time; in fact it is a variation of the vibrating reed. Now it is evident that *QOP* being mounted on *HI*, any movement up and down of *I* will cause *P* to likewise move up and down; but because of the inertia of *P* and since it is on the spring, *O*, it will tend to lag behind slightly if *I* is moved up suddenly, as it is by the pulse beat. What happens, then, with this mechanism is that when a pulse wave comes, lifting all of the movable parts from *J* to *L*, the weight, *P*, is carried upward, it tends, however, to lag behind, but this is prevented

by the set-screw, *W*. The height of the pulse having been reached, the whole system tends to fall. There is, though, no set-screw to prevent the weight lagging back on the downward cycle. Hence it tends to pull away from *W* and leave a break between them. It was thought at first that this would be sufficient to make a good make and break, but it was found that with a break big enough to be effective there was too much chance for secondary waves to come in and disturb the record, so it was necessary to add two other attachments to complete the apparatus.

The first of these was a very light strip of brass mounted on the pivot, *R*, and resting on the fulcrum, *U*. When *P* rises it carries *R* up with it. *S* then falls and makes a contact at *T*. Since *UT* is much longer than *RU*, the use of this extra light lever magnifies the movement at *P* many times. *T* can thus be set so as to catch the peak only, so to speak, of the pulse wave. It was found that this appliance increased the efficiency of the make and break quite a bit.

One other part was added. At *V* was pivoted the bar with a set-screw in it. The end of this set-screw rubs against the weight, *P* and tends to damp its vibrations, thus serving to iron out the subsidiary ones that might make extra contacts. This set-screw can be adjusted to give any desired pressure on *P* and it is set to the point where each pulse beat causes only one complete vibration of *P*. The force necessary is found to vary with the force of the pulse beat, which is found to vary with the pressure. Consequently in practice it is found best to adjust *V* and then leave it set at the point of greatest efficiency, changing the weight *M'* to secure the optimal "kick" from the pulse.

T is mounted on a bit of wood fiber, which insulates it from the rest of the apparatus. *X* is a binding post in connection with it and from *X* a wire runs to whatever electrical recording device—counter or signal marker—is to be used. The other wire lead is connected with the binding post, *Y*.

Sample records obtained by the use of this apparatus are shown. In Fig. 3 a pulse record alone is given, with the time line in seconds. In Fig. 4 both the direct record of the pulse

Fig. 3

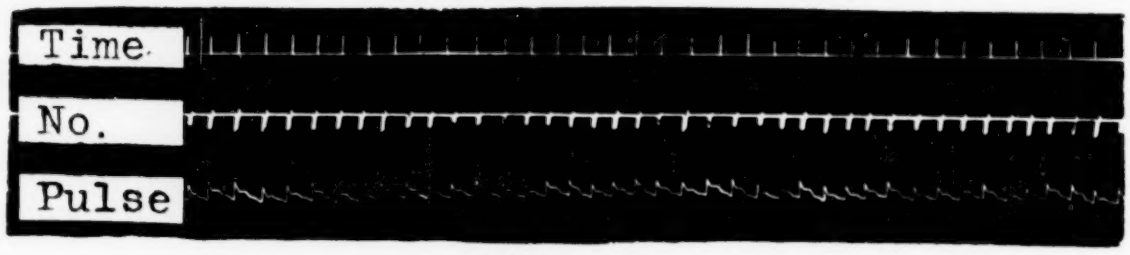


Fig. 4

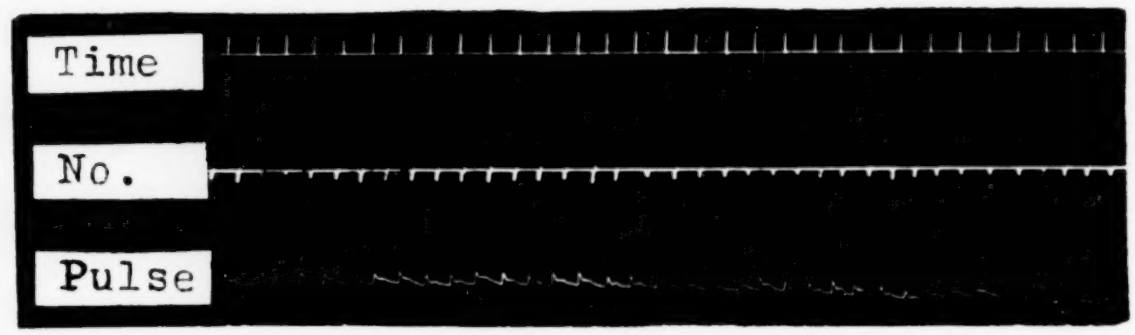


Fig. 5

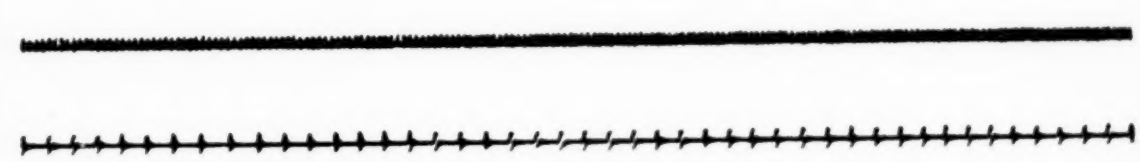


Fig. 6

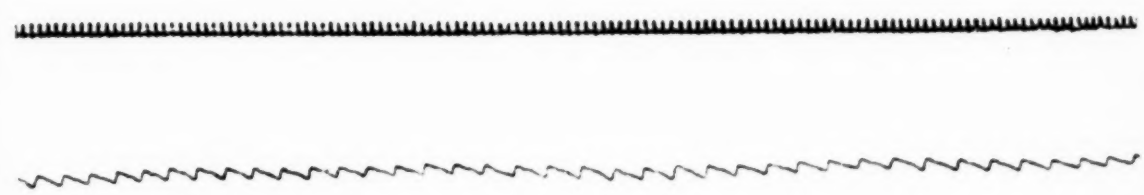


Fig. 7

curve is given and the record of the number of beats. It should be noted that in Fig. 4 a greater weight was used on the pulse with a consequent flattening out of the whole. In Fig. 5 this is still more marked. Fig. 6 is a number record, the time in this case being taken in fifths of a second, and both time and number being recorded with ink writers. Fig. 7 is a pulse record recorded with an ink writer attached in the place of the stylus writing point, and writing directly upon the white paper. It will be noted that this is really only a record of the number of beats, the characteristic form being somewhat distorted by the friction necessary to the type of ink writer used. Doubtless with a little care a better record than this could be secured.

Section 2

A Survey of Devices for Recording the Pulse

In the course of the investigation involved in the construction of the recorder just described the writer has had occasion to make a survey of the literature on the subject. It will, perhaps, be of value to sketch briefly here the main types of apparatus that have been used, together with references and a hint as to the content of some of the references.

An early writer on the recording of the pulse movement is Marey (23). He describes two types of sphygmograph, one working on the principle of the lever, the point of support being the pulse and the record being traced on a moving surface. His second type makes use of pneumatic transmission, by means of a tambour which is mounted on the arm and activated by a lever arm resting against the pulse.

The Dudgeon sphygmograph seems to have been most favorably received by the physiologists and practically every advanced text book contains a description of this instrument. As pictured by Howell (19) it consists of a device that is strapped on the arm so that the button of a metallic spring rests over the radial artery and the movements of the artery are transmitted to a bent lever which magnifies the movement, which is recorded by a writing point, the blackened paper which is used being moved by a clockwork which is strapped

on the wrist as a part of the whole device. The whole is not far different from the apparatus described by Marey.

O. Frank (12) criticized these earlier methods because the lag due to the mass to be moved distorted the record. He devised apparatus to eliminate this factor, the pulse movement being used only to motivate a small mirror, the movement of this mirror being recorded on a light-sensitive surface.

There have been countless modifications of these three basic methods of pulse recording, and only a few of them can be mentioned. Veiel (32) and Schmid (29) made a study of the results obtained by different methods and suggested some modifications. Du Bois-Reymond (5) describes a sphygmograph which consists of a modification of the recording device of the Dudgeon, using a special liquid filled form of Marey's tambour for which he claims superiority in ease of location and certainty of operation. This device, with certain improvements, is described by Fleischer (14). The tambour principle was subjected to wide development. Blix (1) describes a special form for which he claims superiority. François-Franck (13) shows a rather delicate instrument built around the tambour principle, designed to cut down pressure and inertia. He admits that a difficulty is the necessity for immobility of the part explored and concludes that his apparatus is but a new and more precise form of a device previously presented by Brondgeist under the name of Pansphygmograph, because it could be used in exploring any of the arteries commonly studied. Pompilian (28) had a device for supporting a Marey tambour over the pulse and an adjustable tension lever arm carrying a button to rest on the pulse. Guilleminot (15) had a sort of hollow bracelet to go around the arm, with a tube running to a double tambour, one side of which was under pressure from the bracelet, the other from an air chamber. By means of an air pump and a set of valves any desired pressure could be put on the pulse. Pachon (26) points out some of the factors that influence the type of record obtained by all of these methods, with general criticism of technique.

Burton-Opitz in his 'Text-Book of Physiology' gives a

brief bibliography and also descriptions of several sphygmographs. He mentions the apparatus of Vierordt (33), who he says was the first to use the graphic method of investigating the pulse. He describes Marey's tambour (24), and speaks of Czermak (7) who had a mirror device in place of the usual writing lever, the reflected beam of light being recorded on a strip of sensitive paper. He describes the sphygmograph of Dudgeon (10) and gives a reference to that of Petter and Frank (27).

Dodge (8) has perhaps contributed more in this field than any other psychologist. He perfected a device which consisted essentially of a telephone receiver which was placed over the pulse, the current changes which were set up by the pulse beat being recorded by means of a galvanometer. A second type of recorder (9), used by him has already been mentioned in this paper.

Electro-cardiographic methods, while outside the scope of this paper, are of course of some kindred interest and the writer has thought it profitable to include several references to such in the bibliography. Among these are the works of Blumenfeldt (2), of Cohn (6), Eigen (11), and Hill (18).

Of the remaining references given in the bibliography the reader can infer the contents from the title. Two or three of them, notably Shepard (30) and Stevens (31) are given because they contain references to the technique of graphic registration of the pulse.

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A PSYCHOLOGICAL STUDY OF LINGUISTIC ABILITIES WITH REFERENCE TO THE RESULTS OF WORD ASSOCIATION TESTS

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This investigation grew out of a piece of work which was reported in this JOURNAL for October, 1922, and which bears the title 'Differences in the Oral Responses to Words of General and of Local Significance.' We have been interested to learn whether or not the length of response is due to emotional disturbance, as has frequently seemed the case, or due merely to paucity of ideas. Within the following pages we have reported our results from tests designed to throw light on this subject.

The purpose of this investigation was to determine the relations existing between certain other linguistic tests: namely, an Analogies Test, a Proverbs Test, a Sentence-Completion Test, and a Free Association Test; and also to discover the relations between these various linguistic tests themselves:

The tests offered were:

1. A Free Association Test
2. An Analogies Test
3. A Proverbs Test (reasoning by comparison and abstraction)
4. A Sentence-Completion Test

Sixty students of sophomore standing from the University of Texas were selected as subjects. Of this number twenty-six were boys and twenty-four were girls. The group selected was one, as well as could be estimated, of normal distribution. That is to say, the subjects were all members of a psychology class whose grades conformed to the curve; and, aside from their scholastic standing, the instructor of the class passed individual judgment upon the students which conformed to the results already yielded by university grades.

The first two tests, the Free Association and the Analogies Tests, were given individually; while the last two, the Proverbs and the Sentence Completion Tests were given to the group.

The four tests chosen may be described as follows:

1. Free Association Test

As stated above this test was taken as the basis or correlation with the other three tests given. The subject was told that a stimulus word would be given him to which he was to respond with the first word that came into his mind. He was cautioned to answer with only one word and to respond as soon as that came into his mind. Absolute honesty was also asked for from S. Following is a list of the 88 words used:

Bible	X————(Name of dean)
sweet	ideal
Stutz automobile	Curtain Club
McFadden's	Pig
false	Driskill Hotel
crap shooting	cigaret
slow	S. A. E. fraternity
child	over
buzzard	Majestic Theatre
San Marcos	Clark Field
poker	Zeta fraternity
justice	quiz
Maverick Cafe	psychology
Post Road	Dodge automobile
sheep	Arrowhead Club
Co-op	bust
stem	cake
bank check	rush
whistle	swift
automobile	Theta fraternity
beautiful	wicked
fraternity pin	toddling
river	fraternity house
Cosine	heavy

white
date
library
grave digger
Blunderbuss
Griffith's
Phi Mu fraternity
B. Hall
campus
long
drink
Kappa Alpha fraternity
Students' Council
comfort
German
Pi Phi fraternity
Buick automobile
fruit
problems
Cactus Tea Room
Sigma Chi fraternity
hammer
Woman's Building
lion
Ford automobile
prejudice
Crescent Theatre
Lake Austin
cheese
fish
Beta fraternity
afraid
Kappa fraternity
mathematics
butterfly
Newman Hall
Deep Eddy
dance favors
smooth

As may be seen, the above list included both general and specific words—that is, those of both general and local significance. All of these words were thoroughly familiar to the subjects.

A stop watch timed to .01 of a minute was used and as each response was given the time and also the word itself were recorded by the experimenter. Thus both quantitative and qualitative results were obtained.

The method of scoring was twofold:

1. The first method based according to average time of response;

2. The second based upon the response itself and having as its purpose to discover what the normal response was for each stimulus word.

In (1) S was ranked according to the time he took to respond; those taking the least amount of time being placed at the top. In (2) S's were ranked according to conformity to the form; those giving most frequent responses being placed

at the top and those most individual at the bottom of the ranking.

The time of each response was recorded by E with the same stop watch as used in (1).

S was scored according to the average time of each response, and ranked one, two, three, etc., accordingly as he answered most quickly.

3. The two tests (1) and (2) were given individually, but (3) was given to the group. Sheets containing both Arabian and English proverbs were placed before the subjects face downwards. S's were told they were to have five minutes to check each English proverb corresponding to the respective Arabian proverb. At a sign from E the papers were turned over and the test began. An example was given at the head of the list of proverbs.

Following is a copy of the test:

PROVERBS TEST—SCOTT (II.)

Place in the ( ) preceding each English proverb the number of the Arabian proverb to which the English proverb corresponds in meaning, as indicated in the sample.

English Proverbs	Arabian Proverbs
( ) Strike while the iron is hot.	1. Where the will is ready the feet are light.
( ) The best fish swim near the bottom.	2. Weeds require no sowing.
( ) A man never appreciates ashes until he slips on the ice.	3. The sweetest grapes hang highest.
( ) A burden which one chooses is not felt.	4. Sail when the wind blows.
( ) Many are good because they can do no mischief.	5. The results test the work.
( ) Ill nature never needs a tutor.	6. We only know the worth of water when the well is dry.
( ) Shallow brooks are always noisy.	7. Bind the willow while it is young.
( ) The proof of the pudding is in the eating.	8. Empty vessels give the greatest sound.
( ) An old dog will learn no tricks.	9. The cat is honest when the meat is out of reach.

Five minutes was given for the test. Scoring was arranged on a scale of 0–8, (there being 8 pairs of proverbs) and S was

scored 1 for each correct pairing. S's were ranked with the ones making the highest score coming first.

4. Sentence Completion Test

For this test a story entitled 'A New Way to Make People Happy' was selected. Certain words and parts of words omitted, the omissions, of course, to be filled by S. Notice the form as presented to the subjects:

A NEW WAY TO MAKE PEOPLE HAPPY (III.)

Fill in the missing words and parts of words. Each blank represents a part of a word or an entire word, but the length of the blank does not indicate the length of the word.

Massasoit was a ——— Indian chief. He was a philosopher, and he ——— a ——— among his ——— which, if un——— in letter, was ——— ——— in spirit. It was based ——— ——— ——— that happiness ——— ——— relative ———. One day ——————— was ——— a journey ——— Edward Winslow. They were going to Plymouth. Before they reached Plymouth the Indian ——— ——— messenger to the ——— to ——— ——— p———e that Winslow ——— dead. After some hours ——— with ——— appeared ——— the ———. The ——— of the ——— was ——— into ———. "Why ——— ——— ——— w———d that ——— ——— d———d?" asked ———. ———. "To ——— you ——— on his ———," was the ———; "it is a custom of my people."

The forms were placed before S's face downward and at a sign from E were turned over and the test proceeded with as had been directed. Twenty minutes were allowed for the attempt.

The method of scoring was as follows: 2 points were given to each blank filled correctly and in the story where the sentences: "The ——— of ——— was ——— into ———," and "To ——— you ——— or his ———, was the ———" were found, an extra five points credit was given to each sentence if the correct thought was given. The reason for doing this was that these two instances were considered to contain the most significant points and also the most important ones in the story. The author determined these to be the most significant places in the story from other experimenters who had given the test and found likewise that S's least often completed these two sentences correctly.

Scoring was on the basis of 0–100; S's making the highest score being ranked 1 and so on down to the lowest score.

Results

In the discussion of relations of the different tests given let us term the Free Association Test, scored according to average time of response, I.*a*; Free Association Test scored according to conformity to form, I.*b*; Analogies Test, II.; Proverbs Test, III.; and Sentence-Completion Test, IV. As the Free Association Test was chosen as the basis of comparison we correlated I.*a* with I.*b*, I.*a* with II., I.*a* with III., I.*a* with IV. (Table I.), afterwards correlating I.*b* with II., I.*b* with III., I.*b* with IV. (Table II.). Then to obtain further relations, II. was correlated with III. and with IV., and III. with IV. (Table III.).

Table I

(Showing ρ and R of I.*a* with I.*b*, II., III., IV.)

	I.*b*		II.		III.		IV.	
	ρ	r	ρ	r	ρ	r	ρ	r
I.*a*.....	.80	.8135	.79	.8039	.61	.6280	.07	.5881

In computing the coefficient of correlation the Rank-Difference Method was used. This method consisted of:

1. Arranging each of the two series of measurements to be correlated in rank order.

2. Obtaining the difference between the two ranks assigned each case.

3. Squaring each of these differences. (The squares were read from tables of Thorndike.) This result is called $\sum D^2$

4. Using the formula:

$$\rho = 1 - \frac{6\sum D^2}{N(N^2 - 1)}.$$

5. Computing r from ρ also found in tables from Thorndike.

In I.*a*, ranking consisted in arranging in rank order (as explained above), the average time of response for each individual for all eighty-eight words.

TABLE II

(SHOWING ρ AND R OF I.*b*, WITH II., III., IV.)

	II.		III.		IV.	
	ρ	r	ρ	rf	ρ	r
I.*b*.....	.79	.8039	.75	.7654	.43	.4465

TABLE III

(SHOWING ρ AND r OF II. WITH III. AND WITH IV.; ALSO III. WITH IV.)

	III.		IV.	
	ρ	r	ρ	r
II.....	.75	.7654	.58	.5981
III.....			.53	.5479

TABLE IV

(SHOWING ALL CORRELATIONS FOUND BETWEEN TESTS)

	I.*b*		II.		III.		IV.	
	ρ	r	ρ	r	ρ	r	ρ	r
I.*a*.....	.80	.8135	.79	.8039	.61	.6280	.57	.5881
I.*b*.....			.79	.8039	.75	.7654	.43	.4465
II.....					.75	.7654	.58	.5981
III.....							.53	.5479

In I.*b*, frequency tables were found first. For example the stimulus word "Bible" was taken, the different responses of the sixty subjects found, and also the frequency of each response. The sum of these frequency responses was found for each individual.

Each subject was ranked according to his conformity to the group.

We found the coefficient of correlation between I.*a* and I.*b* to be .8135, indicating that a close relation existed between the two tests and pointing out that the subject who responded most quickly to a stimulus word also gave the most frequent response. This point would indicate that the subject giving

the most individual reaction would also, on the average, have a longer reaction time. Furthermore, that the subject with the shorter reaction time was also the more stereotyped individual.

Between I.*a* and II. the coefficient of correlation was found to be .8039, indicating a close relation between these two tests also and furthermore giving evidence that the person responding most quickly would be able to compare two types of thought most efficiently. From this point it might also be assumed that the subject with shortest reaction time, though possibly a bit stereotyped was also most capable of analyzing and comparing.

Likewise, between I.*a* and IV. there existed a close relation—the coefficient of correlation being .5881. It has been claimed by Ebbinghaus that the sentence completion test is a high test of intelligence. Assuming his statement to be true this correlation would indicate that the person most capable of quick response was also the most intelligent.

I.*b* and II. presented a coefficient of correlation of .8039, being the identical coefficient between I.*a* and II. Since it has been found that I.*a* and I.*b* also correlated high, it seems to be true beyond doubt that the subject responding most quickly and also giving the most frequent response was also able to reason most clearly by analysis.

I.*b* and III. yielded a correlation of .7654, further showing that the subject presenting the most frequent response was also capable of discriminating meanings most carefully.

The coefficient of correlation between I.*b* and IV. was found to be .4465, which indicated that the person giving the most frequent response also yielded a score indicative of high intelligence.

II. and III. presented the coefficient of .7654, indicating that the subjects who reasoned best by analogy also were best able to reason by comparison and abstraction.

II. and IV. also gave a fairly high coefficient of correlation: .5981. This would point out that subjects who made the best records in the Analogies Test also were most efficient in the Sentence Completion Test.

III. and IV. further carried out the other results found, presenting a coefficient of correlation of .5479.

A most interesting individual case was found. The subject showing the longest reaction time (.09) also gave the most individual responses (479).

Conclusions

From these results set down above it may be stated that:

1. It has been the popular assumption that long reaction time in free association is indicative of inhibitions, emotional repressions, or complexes. This investigation seems to show that the long reaction time may be explained in quite different terms, namely, in terms of intellectual equipment. It is quite possible to suppose that long reaction time may be due to paucity of ideas, and that this paucity seems to make slow the mental mechanism as groping for scattered objects would necessarily be slower than grabbing for a great array. We may assume that Free Association as told in terms of time is an indicator of intellectual activity as well as of emotional activity.

2. Since the correlation between the Sentence-Completion Test and the Free Association Test, ranked according to time, is .5881, it may be stated with impunity that rather a high grade of intelligence is accompanied by a wealth of ideas. Short reaction time would naturally indicate a superficiality of response, in view of the fact that no time is taken or allowed for deliberation; but a superficiality of response, as we see from the above correlation, arises not from flightiness of ideas or unsteadiness of mind, but rather from a profundity of ideas and higher type of intellectuality. It may be concluded, then, that short reaction time may be due in part to wealth of ideas.

3. Formerly, the idea was held that reaction time alone was a measure of intelligence; recently this belief has been in disrepute. But it seems that the old idea was not entirely wrong, since the Analogies Test, requiring a knowledge of logical relations, the Proverbs Test, calling for reasoning by comparison and abstraction, and the Sentence-Completion

Test, indicating general high intelligence—all three of which are measures of intelligence, show high correlations with short reaction time in the Free Association Test. Therefore, it may be further stated, in regard to short reaction time that it is an indication of intelligence.

4. Viewed from the standpoint of reaction time:

A. The result established between the Free Association Test (I.*a*), scored according to time of response, and the Analogies Test (II.), would seem to suggest that short reaction time indicates a fairly high degree of ability to reason by logical relations. A similar conclusion may be drawn from the relation between short reaction in Free Association (I.*a*) and the Proverbs Test (III.). As a matter of verification to these two statements, it is interesting to note the high relation (.7654) between II. and III.

B. The relations established between Free Association and Sentence-Completion (.5881) suggest the coincidence of short reaction time with high general intelligence.

5. In regard to the matter of conformity of the individual to the norm in free association, it may be noted:

A. The tendency to give responses most frequently is regarded as the normal association tendency. That is to say, the person who gave responses most like the responses given by other persons would be taken as the individual most characteristic of the group, and thereby the most normal. The coefficient of correlation between the Free Association Test, scored according to conformity to the norm (I.*b*) and the Analogies Test being .8039 would indicate that the tendency to give normal responses is concurrent with the recognition of logical relations.

B. The correlation existing between I.*b* and the Proverbs Test (.7654) prompts the assumption that comparison and abstraction are salient characteristics of normality as indicated by association response frequency.

C. Taking into consideration the validity claimed by Ebbinghaus for the Sentence-Completion Test as a measure of general intelligence, observations of results between I.*b* and IV. (Sentence-Completion) show a marked agreement between

normality—in terms of response frequency—and high intelligence. In other words, the most normal person, the person most capable of easy, ordinary response, is the most generally intelligent.

This does not pretend to take into account individuals who might be particularly gifted along some lines, yet not possessing high general intelligence and whose association responses show a large number of individual reactions.

As a re-statement of a point already made, the most interesting item derived from this investigation has been the evident proof that inability to respond quickly to a stimulus word is due, on the whole, not necessarily to complexes or suppressed emotions, but perhaps to a dearth of ideas, a limited vocabulary, and a lack of general intelligence.

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THE ELIMINATION OF CHILDREN'S FEARS

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The investigation of children's fears leads directly to a number of important problems in the genetic study of emotion. At the Johns Hopkins laboratory [1] Dr. John B. Watson has analyzed the process by which fears are acquired in infancy, and has shown that the conditioned reflex formula may apply to the transfer of emotional reactions from original stimuli (pain, loud noises, or loss of bodily support) to various substitute fear objects in the child's environment. This process has been further demonstrated by the author in the case of children from one to four years of age.[2] A study of how children's fears may be reduced or eradicated would seem to be the next point for an experimental attack. Such a study should include an attempt to evaluate, objectively, the various possible methods which laboratory experience has suggested.

The present research, an approach to this problem, was conducted with the advice of Dr. Watson, by means of a subvention granted by the Laura Spelman Rockefeller Memorial to the Institute of Educational Research of Teachers College.

The subjects, 70 children from 3 months to 7 years of age, were maintained in an institution for the temporary care of children. Admission to this institution depended as a rule upon conditions which made it difficult or impossible to keep the children at home: a case of illness in the family, the separation of father and mother, or an occupation which kept the mother away from home for a part of the day. As there was a charge for weekly care, those homes which were in actual poverty were not represented; the economic and social

[1] Watson and Rayner, 'Studies in Infant Psychology,' *Scientific Monthly*, December, 1921.

[2] 'Conditioned Fear in Children,' to be published in 1924.

status of the parents, as well as the results of our intelligence tests (Kuhlmann and Terman) would indicate that this group of children was normal, and superior to the average for orphan asylums and similar institutions. As the danger of contagion is great in a group so constantly changing, a very thorough medical examination eliminated all those with symptoms of infection, and even those decidedly below normal in nutrition or general development. Our laboratory could not determine the admission and discharge of children, nor interfere in the prescribed routine of eating, sleeping and play. It was possible however for the experimenter to live in the building with the children in order to become acquainted with them in their usual environment, to observe them continuously for days at a time, and to take them daily, or oftener if desirable, to the laboratory where observations could be made under specifically controlled conditions.

In our selection of children from this group, we attempted to find those who would show a marked degree of fear under conditions normally evoking positive (pleasant) or mildly negative (unpleasant) responses. A wide range of situations were presented in a fairly standardized way to all of the children: such as being left alone, being in a dark room, being with other children who showed fear, the sudden presentation of a snake, a white rat, a rabbit, a frog, false faces, loud sounds, etc. This procedure served to expose fear trends if they were already present; it was not designed as a conditioning process, but merely as a method of revealing prior conditionings. In the majority of the children tested, our standard situations failed to arouse observable negative responses. This survey of children's fears is reported in another article.

When specific fears were demonstrated, our next step was to attempt their removal. By what devices could we eliminate these harmful reactions, which in many cases were subject to diffusion, and were interfering with the formation of useful attitudes and necessary habits? Our method or combination of methods depended upon the type of case presented and the manner in which treatment was received, as

well as upon such external circumstances as quarantines, and the length of time the child was likely to remain in the institution.

The Method of Elimination through Disuse

A common assumption with regard to children's fears is that they will die out if left alone, *i.e.*, if the child is carefully shielded from stimuli which would tend to re-arouse the fear. "Elimination through disuse" is the name given to this process. The following cases from our records provide suggestive material:

Case 1.—Rose D. Age 21 months. General situation: sitting in play-pen with other children, none of whom showed specific fears. A rabbit was introduced from behind a screen.

Jan. 19. At sight of the rabbit, Rose burst into tears, her crying lessened when the experimenter picked up the rabbit, but again increased when the rabbit was put back on the floor. At the removal of the rabbit she quieted down, accepted a cracker, and presently returned to her blocks.

Feb. 5. After 2 weeks the situation was repeated. She cried and trembled upon seeing the rabbit. E. (the experimenter) sat on the floor between Rose and the rabbit; she continued to cry for several minutes. E. tried to divert her attention with the peg-board; she finally stopped crying, but continued to watch the rabbit and would not attempt to play.

Case 8.—Bobby G. Age 30 months.

Dec. 6. Bobby showed a slight fear response when a rat was presented in a box He looked at it from a distance of several feet, drew back and cried. A 3-day period of training followed bringing Bobby to the point where he tolerated a rat in the open pen in which he was playing, and even touched it without overt fear indications. No further stimulation with the rat occurred until

Jan. 30. After nearly two months of no experience with the specific stimulus, Bobby was again brought into the laboratory. While he was playing in the pen, E. appeared, with a rat held in her hand. Bobby jumped up, ran outside the pen, and cried. The rat having been returned to its box, Bobby ran to E., held her hand, and showed marked disturbance.

Case 33.—Eleanor J. Age 21 months.

Jan. 17. While playing in the pen, a frog was introduced from behind her. She watched, came nearer, and finally touched it. The frog jumped. She withdrew and when later presented with the frog, shook her head and pushed the experimenter's hand away violently.

March 26. After two months of no further experience with animals, Eleanor was taken to the laboratory and offered the frog. When the frog hopped she drew back, ran from the pen and cried.

These and similar cases show that an interval of 'disuse,' extending over a period of weeks or months, may not result in

eliminating a fear response, and that when other conditions are approximately constant there may be no diminution in the degree of fear manifested. From our experience, it would appear to be an unsafe method to attempt the cure of a fear trend by ignoring it.

The Method of Verbal Appeal

As most of our subjects were under four years of age, the possibilities of verbal analysis and control were very limited. We attempted to find how much we could accomplish toward breaking down a negative reaction by merely talking about the fear-object, endeavoring to keep it in the child's attention, and connecting it verbally with pleasant experiences. This method showed no applicability except in the case of one subject, Jean E., a girl in her fifth year. At the initial presentation of the rabbit a marked fear response was registered. This was followed by ten minutes daily conversation about the rabbit; to hold her interest the experimenter introduced such devices as the picture book of 'Peter Rabbit,' toy rabbits, and rabbits drawn or modelled from plastocene. Brief stories were used, and there was always a reference to the 'real' rabbit as well. On such occasions she would say, "Where is your rabbit?" or "Show me your rabbit," or once "I touched your rabbit, and stroked it, and it never cried." (This latter was pure make-believe, and an interesting example of projection.) However, when the rabbit was actually presented again, at the end of a week, her reaction was practically the same as at the first encounter. She jumped up from her play and retreated; when coaxed, she reluctantly touched the rabbit while the experimenter held it; when the animal was put down on the floor she sobbed "Put it away," "Take it," and ran about the room frightened and distracted. She had learned to speak freely of rabbits, but this altered verbalization apparently was not accompanied by any change in her response to the rabbit itself. The experiment was interrupted after another three days of the same procedure, at the end of which time Jean left the institution with her initial fear patterns intact, so far as we could tell. It

seems likely that many hours of training in the toleration of symbols may have little or no modifying effect on a mass reaction to the primary stimulus.

The Method of Negative Adaptation

This method is based on the theory that familiarity breeds indifference: if the stimulation is repeated often enough, monotonously, the subject finally becomes used to it and tempers his response accordingly.

Case 17.—Godfried W. Age 3 years.

A white rat was introduced from behind a screen. Godfried sat quietly for a few minutes, watching the rat with close attention. He then began to cry, made avertive movements with his hands and feet, and finally withdrew as far as possible from the animal. At the next presentation of the rat, Godfried did not cry; he advanced cautiously, making quick startled withdrawals whenever the animal moved.

A few days later when the same situation was presented, Godfried smiled and said, "Put it down on the floor." After three hours the rat was again brought in and allowed to run free in the pen. It scurried about and occasionally came very near him, but Godfried made no attempt to withdraw even when the animal advanced and touched him.

In this case, with practically no reëducative measures except repeated stimulation, Godfried conquered his specific fear. The experiment was not carried to the point where he showed a distinct positive reaction to rats, but he had developed a socially satisfactory attitude. As a strictly non-verbal approach, the method of negative adaptation is undoubtedly useful with infants and animals. In actual practice, however, we find very few fears in children of the pre-language period, and with the older children it is inefficient to eliminate the degree of control, however slight, which language may afford.

Furthermore, with all but a few of our fear-objects the aim was not indifference, which negative adaptation implies, but something farther along the scale toward an acceptance reaction.

From our experience in general, it would appear that the repeated presentation of a feared object, with no auxiliary attempt to eliminate the fear, is more likely to produce a summation effect than an adaptation. With Godfried (the case just quoted) the loss of his resistance was possibly due to the fact that he had been afraid the animal would bite him. This fear, unrealized, was gradually overcome.

The Method of Repression

In the home, as well as in the school and playground, social repression is perhaps the simplest and most common method of dealing with fear symptoms . . . a method, which, we may commonly note, often fails to remove the roots of the fear. As there are already too many examples of the maladaptive results of repression, we shall not attempt to add to their number. In our laboratory we used no repressive punishment, but within a group of children the familiar situations of ridicule, social teasing and scolding frequently appeared. Because of shame, a child might try to contain his fears without overt expression, but after a certain point had been reached, the reaction appeared notwithstanding.

Case 41.—Arthur G. Age 4 years.

Arthur was shown the frogs in an aquarium, no other children being present. He cried, said "they bite," and ran out of the play-pen. Later, however, he was brought into the room with four other boys; he swaggered up to the aquarium, pressing ahead of the others who were with him. When one of his companions picked up a frog and turned to him with it, he screamed and fled; at this he was chased and made fun of, but with naturally no lessening of the fear on this particular occasion.

Three boys standing around the aquarium each cried "Give me one," holding out their hands for a frog. But when the frog was offered they all precipitously withdrew. When two girls (4 years old) sang out to Sidney (age 3) "Sidney is afraid, Sidney is afraid," Sidney nodded his head in assent . . . illustrating what often happens in the use of social ridicule: the emotion is re-suggested and entrenched, rather than stamped out.

The Method of Distraction

A convenient method, used frequently and with fair results, involves offering the subject a substitute activity. In order to capture a safety pin from the baby's hand and still preserve peace, its attention may be distracted with another toy, while you steal away the pin. Such a device, known to every mother, may be applied to the problem of eliminating fear responses. Arthur, whose fear of frogs had received some attention from us, wished to play with a set of crayons kept in the laboratory. We placed the crayons close to a frog on the table. Arthur stepped forward cautiously; keeping his gaze

on the frog, he grabbed paper and crayons and showed alacrity in darting out of the danger zone. The experience, however, seemed to reassure him. "I ran over there and got it," he told us, "He didn't bite me. Tomorrow I'll put it in a little box and bring it home." At one stage of his fear of the rabbit, Sidney would whine whenever the rabbit was brought near, but he could readily be diverted by conversation about the rabbit's name, or some innocuous detail. For verbal distraction the constant presence of a grown-up is of course necessary; this introduces factors which are not always advantageous (such as reliance upon adult protection). Essentially, distraction soothes a fear response by inducing the child temporarily to forget the fear-object. (Substitution of an alternate stimulus-response system.) This may fail to result in any permanent reduction of the fear trend. Where the situation is properly managed, however, distraction passes over into a method which we have found distinctly useful, and which will now be described.

The Method of Direct Conditioning

It is probable that each of our methods involves conditioning in one form or another. Under this heading, however, we include all specific attempts to associate with the fear-object a definite stimulus, capable of arousing a positive (pleasant) reaction. The hunger motive appears to be the most effective for use in this connection. During a period of craving for food, the child is placed in a high chair and given something to eat. The fear-object is brought in, starting a negative response. It is then moved away gradually until it is at a sufficient distance not to interfere with the child's eating. The relative strength of the fear impulse and the hunger impulse may be gauged by the distance to which it is necessary to remove the fear-object. While the child is eating, the object is slowly brought nearer to the table, then placed upon the table, and finally as the tolerance increases it is brought close enough to be touched. Since we could not interfere with the regular schedule of meals, we chose the time of the mid-morning lunch for the experiment. This

usually assured some degree of interest in the food, and corresponding success in our treatment. The effectiveness of this method increases greatly as the hunger grows, at least up to a certain point. The case of Peter (reported in detail elsewhere) illustrates our procedure; one of our most serious problem cases, he was treated by the method daily or twice daily for a period of two months. The laboratory notes for the first and the last days of the training period show an improvement which we were able to attribute specifically to the training measures used.

Case 30.—Peter. Age 2 years, 10 months.

March 10, 10:15 A.M. Peter sitting in high chair, eating candy. Experimenter entered room with a rabbit in an open meshed wire cage. The rabbit was placed on the table 4 feet from Peter who immediately began to cry, insisting that the rabbit be taken away. Continued crying until the rabbit was put down 20 feet away. He then started again on the candy, but continued to fuss, "I want you to put Bunny outside." After three minutes he once more burst into tears; the rabbit was removed.

April 29, 9:55 A.M. Peter standing in high chair, looking out of the window. He inquired, "Where is the rabbit?" The rabbit was put down on the chair at Peter's feet. Peter patted him, tried to pick him up, but finding the rabbit too heavy asked the experimenter to help in lifting him to the window sill, where he played with him for several minutes.

This method obviously requires delicate handling. Two response systems are being dealt with: food leading to a positive reaction, and fear-object leading to a negative reaction. The desired conditioning should result in transforming the fear-object into a source of positive response (substitute stimulus). But a careless manipulator could readily produce the reverse result, attaching a fear reaction to the sight of food.

The Method of Social Imitation

We have used this method extensively, as it was one of the first to show signs of yielding results.

Case 8.—Bobby G. Age 30 months.

Bobby was playing in the pen with Mary and Laurel. The rabbit was introduced in a basket. Bobby cried "No, no," and motioned for the experimenter to remove it. The two girls, however, ran up readily enough, looked in at the rabbit and talked excitedly. Bobby became promptly interested, said "What? Me see," and ran forward, his curiosity and assertiveness in the social situation overmastering other impulses.

Case 54.—Vincent W. Age 21 months.

Jan. 19. Vincent showed no fear of the rabbit, even when it was pushed against his hands or face. His only response was to laugh and reach for the rabbit's fur. On the same day he was taken into the pen with Rosey, who cried at the sight of the rabbit. Vincent immediately developed a fear response; in the ordinary playroom situation he would pay no attention to her crying, but in connection with the rabbit, her distress had a marked suggestion value. The fear transferred in this way persisted for over two weeks.

Feb. 6. Eli and Herbert were in the play-pen with the rabbit. When Vincent was brought in, he remained cautiously standing at some distance. Eli led Vincent over to the rabbit, and induced him to touch the animal. Vincent laughed.

The second case illustrated a fear socially induced (this is perhaps the most common source of maladjustive fear trends) and the later removal of the fear by social suggestion. Many of the fears we studied pointed to an origin in a specific traumatic experience; it would probably have been a valuable aid in our procedure, had we been able to trace the developmental history of each of these fears. It was usually impossible to do this, however, in view of the institutional life of our subjects, and the fact that parents, even when they could be reached and consulted, were as a rule ignorant of their children's emotional mishaps.

Summary

In our study of methods for removing fear responses, we found unqualified success with only two. By the method of direct conditioning we associated the fear-object with a craving-object, and replaced the fear by a positive response. By the method of social imitation we allowed the subject to share, under controlled conditions, the social activity of a group of children especially chosen with a view to prestige effect. Verbal appeal, elimination through disuse, negative adaptation, 'repression,' and 'distraction' were methods which proved sometimes effective but were not to be relied upon unless used in combination with other methods. It should be remarked that apart from laboratory analysis we have rarely used any of the above procedures in pure form. Our aim has been to cure the fear, by the group of devices most appropriate at any given stage of treatment.

AN EXPERIMENTAL ISOLATION OF HIGHER LEVEL HABITS

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Since the pioneer work in the psychology of learning the conception of a habit as being composed of part-habits of different degrees of complexity has been well recognized. This hierarchical character has been brought out in experimental work usually by exhibiting plateaus in the curve of learning—but which are often of course ambiguous in interpretation; by introspective analysis of mental attitudes; and by sampling—*e.g.*, by interrupting from time to time a series of trials at stylus maze learning with attempts to describe graphically the general course of the true path.

The writer has tried the method of exhibiting some of the higher-level habits directly by training different groups of subjects in habits varying in their simplest component part-reactions, but identical in some of their more general part-reactions.

The type of performance chosen was that of substitution, because here the identifiability of the particular part-reaction (particular paired-associates) and their ready manipulation and independent change renders possible a high degree of control over the overlapping of the respective habits as well as differentiation of different levels of generality in the whole performance. The material was in the form of printed sheets of the ten digits *1*, *2*, etc., to *0*, arranged in fifteen horizontal rows, twenty to a row, in irregular order but two of each to the row, with ample spacing; and bearing a code printed at the top showing the ten digits and their corresponding letters.

I. In the first experiment, three sets of subjects were used, consisting of equal divisions (twenty-one in each) of a class in introductory psychology. No clue as to the general object of the experiment was given further than that it was a learning

test, and each student was left to himself to discover whatever relations obtained between the codes used by him in his successive trials. Rivalry was deliberately stimulated without suggesting differences in kind of work done by different individuals by having the students divided according to seating rows in the lecture room and by maintaining competition between the rows. Five-minute work periods were set by the instructor at the beginning of each lecture hour, five times a week. Each student noted his own total of substitutions made and entered this on his privately kept table and graph of his learning. The plan of the work given the different groups was as follows. Group *S* was given the same code day after day. Group *C* was given codes changing completely from day to day. Group *I* was given codes from day to day that were expected to show interference; each day's code consisting of five new letters not used the previous day, and five old letters used in the same digit-letter pairs as on the previous day. (One requirement for the production of interference phenomena is that certain of the responses to cues be identical in the two interfering habits while certain others are distinct.)

The rates of learning by the three different groups are presented graphically in Fig. 1, in terms of average number of substitutions made by each group in each five-minute practice period. Inspection of the curves shows that the group practicing on exactly the same habit day after day (group *S*) improved the most rapidly; the group practicing on successive days on habits all similar in general nature but distinctly different in the specific elements (group *C*) improved less rapidly; while the group practicing successively on habits similar in general nature but in the specific elements fifty per cent. identical and fifty per cent. different (group *I*) improved least rapidly.

A few words on analysis of the *S*, *C*, and *I* materials for learning are in order. But first it is to be remarked that the whole performance of filling out a substitution test blank involves attitudes and responses of many different levels. Substituting the letter 'r' for the digit '6' is a fairly specific, definite act; and as long as the cue '6' is meant to lead to the

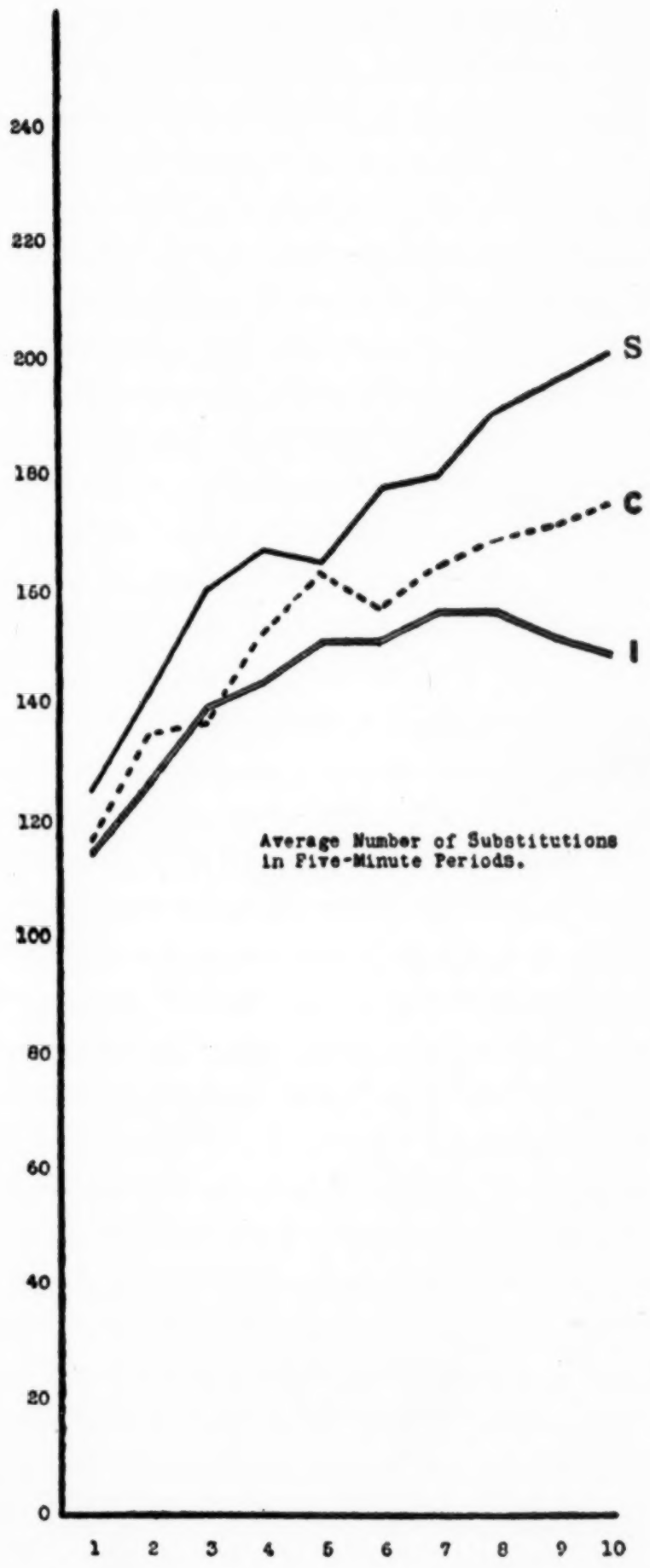

FIG. 1

response 'r' every time the learning of the act is by itself both simple and straightforward. We may disregard the fact that

the substituting involves the specific calling into play here of such previously acquired responses as reading the cue as '6,' holding the pencil just so, writing the letter 'r' in response to the 'thought' of 'r,' etc.; we are here interested only in the new responses called for. Beside the fixing of the particular digit-letter associations there are to be learned incidentally more general habits, such as that of writing a letter under each digit seen, that of glancing to the top of the sheet to get the associates, that of forming each letter with an economy of stroke and time, (probably) that of working competitively for the seat row as against other seat rows. Here again we may omit reference to, as irrelevant, the simply inextricably interwoven habits of all shades of generality and specificity that are involved in the act but are already part of the subject's equipment and not matters to be learned; *e.g.*, holding and writing with a pencil, holding writing paper with left hand, working as a member of a group, holding one's head semi-erect, etc. We may now state the differences between the tasks of our three working groups in terms of a distinction to be drawn between the very specific and particular habits involved in fixing and using given associations such as between '8' and 'm,' and the array of more and more general habits just enumerated that we may call 'substituting generally when for the digits "1," "2," etc., one is to supply letters, as shown in a code above.'

The task assigned group *S* was to learn to substitute-in-general-in-this-general-situation but also to learn one single associate for each of the ten stimulus-digits. This same complex of performances was drilled day after day. Group *C* was assigned the learning of the same response of substituting-in-general-in-this-general-situation but while this was being trained continuously from trial to trial, the group had to practice anew at each trial the specific habits of using the particular digit-letter associates assigned for that trial. Group *S* could presumably have started ultimately upon a practice period with the whole habit-complex already completely learned: group *C* could never hope for this and hence was doomed to being forced to learn at every trial. The

task of group *I*, finally, differed from that of group *S* exactly as did that of group *C*; but contained the additional difficulty of requiring the un-learning or at least inhibitory control of certain specific digit-letter habits just previously acquired.

The curves speak for themselves. The acquisition of an entire complex of habits—a story of integration into a more or less permanent unified hierarchy—proceeds clearly at an acceleration superior to that attainable in learning when a complete permanent learning of the whole down to its details is impossible. Again, the further impediments to learning in those situations involving interference effects are plainly shown.

II. A second experiment was carried out in amplification of two points in the former study. In this case only two groups of subjects were used, working by identically the same procedure as did the groups *S* and *C*. The same type of material was used as before, the members of another class serving as subjects, and working now in four-minute periods.

For one thing, the conformation of the three curves in Fig. 1, may have suggested the criticism that since the order or ranking of achievement of the first three groups in the late trials is the same as in the first trial, we have evidence resembling suspiciously that offered for the well-known principle that individual differences tend to be increased by practice. But the amount and rate of increase in differentiation between group scores is clearly greater than should be expected in the practice effects upon individual differences, to judge from published measurements of these. Again, the slump in the *I* curve after the fifth day would argue for the potency of some other factor than original individual differences alone. A more definite settling of the point was reached by extending the practice beyond the 10th trial, to determine whether any distinct qualitative difference in the curves then appeared.

The results, graphed in Fig. 2, show a rate of acquisition, of the *S* habit-complex that for eighteen trials, at least, remains practically constant. How long this rate of improvement would be maintained before the negative acceleration preceding the inevitable 'physiological limit' is reached,

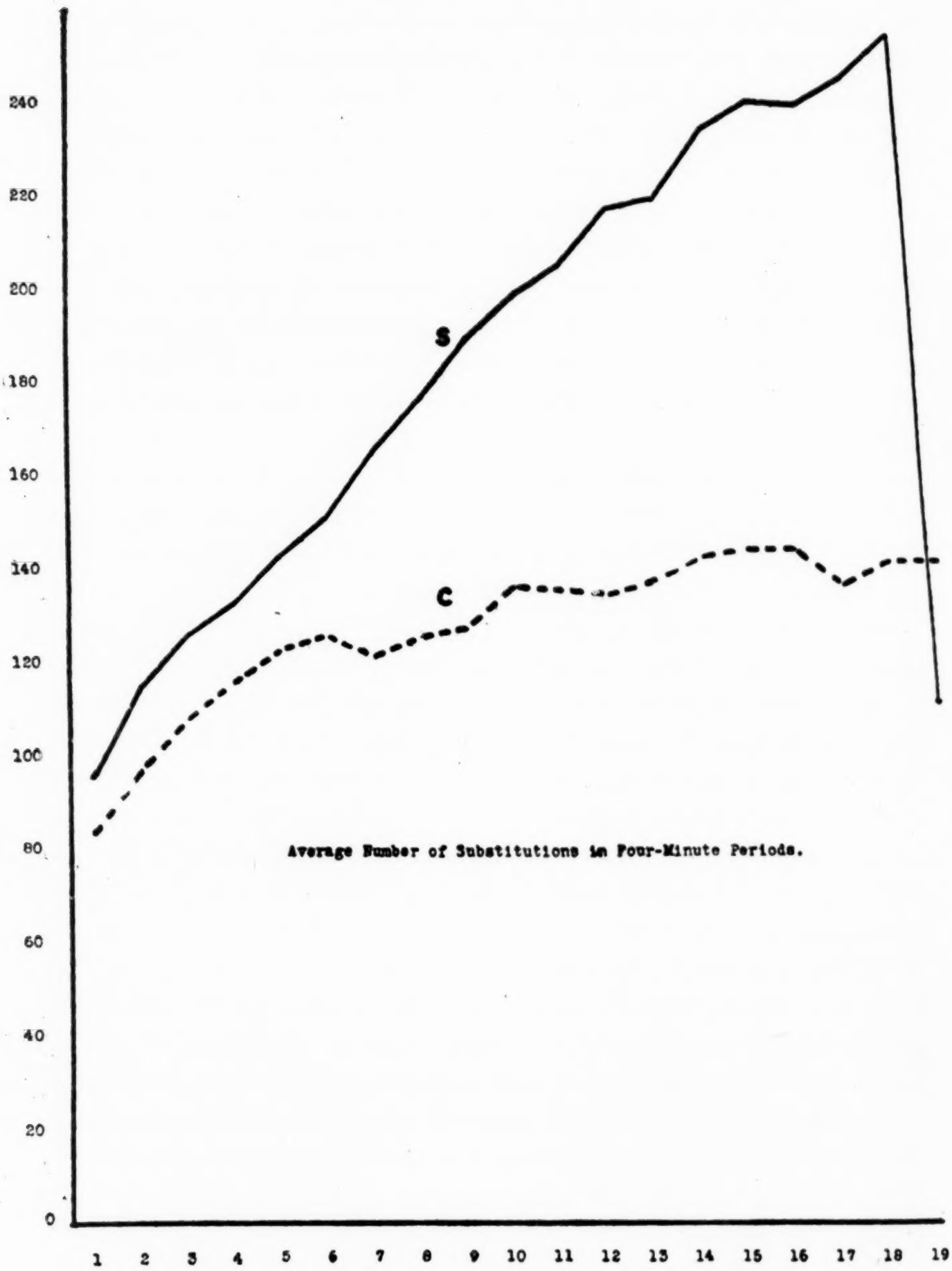

FIG. 2

cannot be said. In contrast with this, the rate of acquiring the *C* habit-complex seems to have diminished fairly constantly, indeed to have become negligible for the last five of the eighteen trials.

An interpretative suggestion may be made. It is possible that in the *S* curve in both experiments we have not gotten beyond the 'initial spurt' for learning that habit-complex, while in the *C* curves we see this spurt already passed or passing—the explanation here to be sought in the fact that the *S* response-complex contains more constituent parts of a learnable sort than does the *C* response-complex.

After the eighteen learning trials a test trial was set (but not announced as such) in which both groups were given an entirely new code to learn. For the *C* group this was, of course, in nature only a continuation of the learning tasks previously set, and the score consequently shows no change. For the *S* group, however, this constituted for the first time a radical change in the use of specific lower-order responses. Put otherwise, it found the subjects equipped with the wrong attitude or general response—that of expecting and being 'used' to the same code throughout the various trials. They were to that extent poorly equipped for a change in the particular responses called for by the novel situation.

The loss of efficiency by the *S* group on the 19th trial is striking—especially considering that this is a group average for twenty-one individuals; and anticipation as to changes in efficiency in later trials would make interesting speculation. The writer has made an experimental study indirectly bearing upon this to be published elsewhere.

In summary: by employing a type of response-complex (substitution) that involves part-responses readily changeable and controllable, and by assigning to different learning-groups problems calculated to arouse over a series of trials different combinations of general and of particular responses, clear differentiations in rates of learning were exhibited as due to these different combinations.

GROUP JUDGMENTS IN THE FIELD OF LIFTED WEIGHTS

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A brief paper by Francis Galton, entitled 'Vox Populi,' (*Nature*, Vol. 75, 1907), begins with these words: "In these democratic days, any investigation into the trustworthiness and peculiarities of popular judgments is of interest." Since that paper was written many studies have been made in which groups of judges have rated such things as personal character traits and objects having degrees of esthetic merit, the reliability of the judgments being estimated by the agreement of group with group. But in the field of ethical and of esthetic matters it is sometimes felt that this test of consistency is not so final as some objective physical measure would be. The groups may agree, but are they therefore right? In view of this question it seems important to test the accuracy of group judgments in situations where there are accepted physical measures by which to check the results. The issue may be phrased as follows: Is the judgment of a group of persons any better than the judgment of the average member of the group? This paper reports an experiment devised to answer the question in the field of lifted weights.

A series of 10 weights was used. These were small glass bottles, uniform in size and appearance, loaded with shot and cotton. They ranged in weight from 16 grams to 17.6 grams, the heaviest thus representing an increment of 1/10 of the lightest. The weights varied by equal objective steps Hence each one differed from its neighbor by 1/90 of the lightest weight. These intervals are small enough to make the judgments of individual subjects very unreliable. If one were to define the liminal interval as that which 75 per cent. and no more of the subjects judged correctly, then these smallest intervals would be far below the threshold. In fact,

only 85 per cent. of the subjects were able to judge the difference between lightest and heaviest correctly.

The subjects of the experiment were 200 students in the Southern Branch of the University of California. All but 3 were young women. Each person arranged the bottles according to his estimate from heaviest to lightest. Each was allowed to take plenty of time and to make any rearrangements desired. The order arrived at by each person was correlated with the true order by the formula $r = I - \frac{6 \text{ sum } D^2}{n(n^2 - I)}$. This gave 200 coefficients of correlation. Their range is very great, being + .95 to − .81. The mean is + .41 and the S.D. 32.9.

The next step was to combine the judges into groups. A composite judgment on the order of weights was made by averaging the positions assigned to each weight by the first 5 persons. There were in all 40 mutually exclusive groups with 5 in a group. The composite order for each group of 5 was correlated with the true order. The mean of the 40 coefficients so obtained is + .68, S.D. 19.2. The subjects were then combined into 20 mutually exclusive groups with 10 in a group. The mean coefficient rises to + .79, S.D. 16.5. The next grouping was to combine the subjects by twenties into 10 groups. The mean coefficient is + .86. Finally the judgments of 4 groups with 50 persons in a group were compared with the true order of weights with the result that the 4 coefficients so reached are + .92, + .92, + .94, and + .95. These figures are shown in Table I. in which the first column at the left gives the ranges of correlation coefficients extending from + .99 to − .90. The second column from the left (headed "One") shows the frequencies of the individual correlations at each of these ranges. For example there were 5 persons whose arrangement of the weights correlated with the true order to an extent represented by the range 90–99. The third column of the table (headed "Five") shows the frequencies of certain correlations attained by groups of five persons. Thus there was one such group whose judgments correlated with the true order by + .90 to + .99. The

TABLE I

FREQUENCIES OF COEFFICIENTS OF CORRELATION, SHOWING THE RELATION BETWEEN JUDGMENTS OF GROUPS OF DIFFERENT SIZES AND THE TRUE ORDER OF WEIGHTS

Coefficients	Size of Group				
	One	Five	Ten	Twenty	Fifty
90–99.....	5	1	3	5	4
80–89.....	12	12	10	3	
70–79.....	20	13	5	1	
60–69.....	20	5	1	1	
50–59.....	35	2	0		
40–49.....	29	3	0		
30–39.....	15	2	0		
20–29.....	21	1	0		
10–19.....	11	0	1		
0– 9.....	8	1			
−10– − 1...	8				
−20– −11...	6				
−30– −21...	2				
−40– −31...	3				
−50– −41...	1				
−60– −51...	3				
−70– −61...	0				
−80– −71...	0				
−90– −81...	1				
Mean=	+.41	+.68	+.79	+.86	+.94

remaining columns show frequencies of correlations for the subjects as grouped by Tens, Twenties and Fifties. Each column represents the 200 subjects grouped into classes of varying size. The table shows that these persons whose mean attainment as individuals is + .41 can, when combined into groups, reach a mean correlation of + .94 with the true order. In other words, the results of the group are distinctly superior to the results of the average member, and are equal to those of the best members.